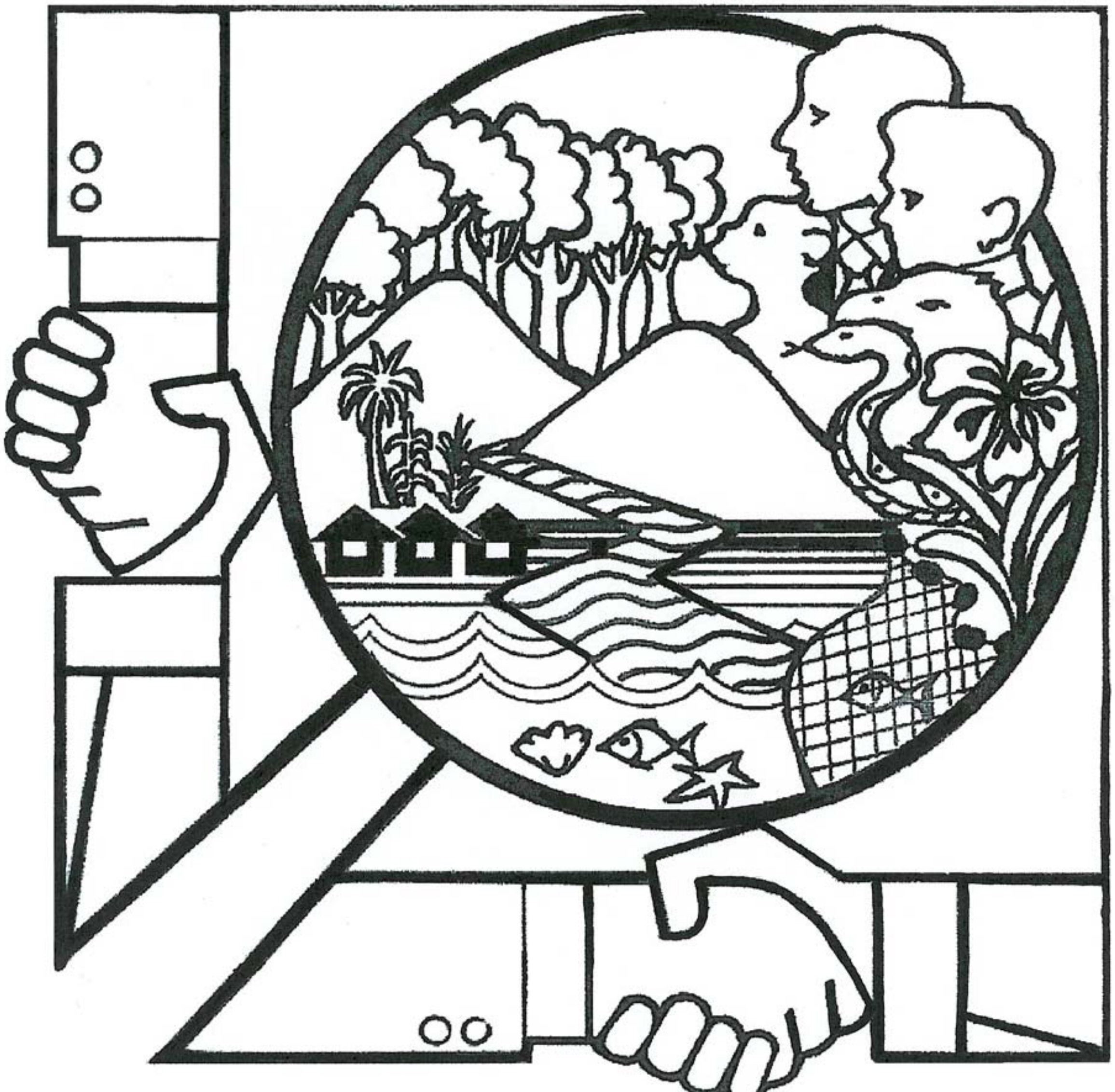
Assessing the Diversity of Selected Arthropods in Cabbage-Growing Areas in Mt. Malindang, Misamis Occidental



Emma M. Sabado
Stephen G. Reyes
Esteban T. Padogdog, Jr.

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

Assessing the Diversity of Selected Arthropods in Cabbage-Growing Areas in Mt. Malindang, Misamis Occidental

Emma M. Sabado
Stephen G. Reyes
Esteban T. Padogdog, Jr.

under the

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.

Printed by NJP Printmakers Incorporated, Quezon City, Philippines

ISBN 971-560-106-5

Funding for BRP is provided by the Netherlands Ministry for Development Cooperation (DGIS) through the Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA).

Contents

Acknowledgments

Thine, O LORD, is the greatness, and the power, and the glory, and the victory, and the majesty: for all that is in the heaven and in the earth is thine; thine is the kingdom, O LORD, and thou art exalted as head above all.

Both riches and honor come of thee, and thou reignest over all: and in thine hand is power and might; and in thine hand it is to make great, and to give strength unto all. Now, therefore, our GOD, we thank thee, and praise thy glorious name.
I Chronicles 29:11-13

We would like to acknowledge GOD's omnipotence, omniscience, and omnipresence, which made us successful in fulfilling our responsibilities as BRP researchers. To HIM be the glory!

Our heartfelt gratitude and appreciation for the financial and technical support generously extended by the Biodiversity Research Programme (BRP) and SEARCA. Likewise we would like to thank our institutions, the Mindanao State University at Marawi and the University of the Philippines Los Baños for allowing us to participate as researchers in the BRP.

We are most grateful to Dr. Lijbert Brussaard and Dr. Leontine Visser who had shared their knowledge and expertise, from the revision of the proposal until the completion of this report.

Thanks are also due to the following: Evrin Dris, the former research assistant of the project who labored much in laying the groundwork; the local partners from the three barangays of Don Victoriano, Misamis Occidental for their cooperation, diligence, and patience in conducting the research; local and municipal government officials of Don Victoriano especially Barangay Captain Sergio Barimbao of Mansawan, and Municipal Agricultural Officer Bert Cajeta, for their support to the project; Virginia Cagas and Ronelyn Tautu-an, Department of Agriculture technicians, for their help in conducting the meetings and for their friendship; Lorenzo Buyog, our landlord, for making our stay in Mt. Malindang meaningful and comfortable in spite of the difficulties; Alice Guimala, Jovial Anoling, and Pershing King of the Programme Management Office (PMO) for their administrative help and encouragement when life as BRP researchers seemed unbearable; Hamsir Mamasalagat for typing the report; Dr. Mariliza Ticsay who always followed up on our "never-ending requests" to the Joint Programme Committee (JPC); Dr. Grace Bacaltos and Dr. Oliva Canencia who shared our predicament as BRP researchers but still encouraged us to make it to the end; Mr. Carlo Custodio, the PMO manager, for the challenges which contributed much to our growth as researchers; colleagues in our respective departments, especially our chairman, for the consideration when classes had to be given up in favor of the BRP; and to our prayer warriors, members of the Bible Baptist Church, Pagadian City, especially Mrs. Camila Arballo and Rev. Ebenezer Asis ("And all things, whatsoever ye shall ask in prayer, believing, ye shall receive." *Matt. 21:22*) for their prayers to GOD to keep us from any danger while doing the research in Mt. Malindang.

Finally, we would like to thank our spouses for bearing our responsibilities wholeheartedly while we were away from home, and for their trust, loving support, and understanding which enabled us to conduct the research and finish this report.

List of Figures

List of Tables

Abstract

Biodiversity of arthropods was assessed in cabbage fields of seven local partners in three upland barangays of Don Victoriano, Misamis Occidental. These municipalities included Nueva Vista, popularly known as Mansawan, Gandawan, and Lake Duminagat. Cabbage fields varied in size (60-836 m^2) and slope (20-40°).

The main hypothesis is that farms nearer the forest would have higher diversity compared with those farther away. Moreover, parasites and predators would be more abundant in farms closer to the forest. Species richness, measured using Margaleff's index, did not significantly differ among treatments for the three sites. Correspondence analysis also showed general uniformity of species richness among sites and treatments.

Several classes of arthropods were found associated with cabbage. The more numerous included insects, spiders, sowbugs, and amphipods. Insects dominated these arthropods comprising 10 orders belonging to 60 families. Detrivores include various flies, gnats, and their relatives, collembola, termites, sowbugs, and millipedes. The diamondback moth or DBM, [*Plutella xylostella* (Linn.)], was the major pest of cabbage, which limited production and reduced yield. Populations from the three sites, however, did not differ significantly. Spiders dominated the predatory guild. Spider numbers were significantly more abundant in Gandawan and Lake Duminagat; among treatments, the farm near the forest harbored significantly more spiders than the sprayed and unsprayed cabbage farms.

Other insect pests observed included the cabbage looper [*Trichoplusia ni* (Hubner)], cabbage worm *[Crocidolomia pavonana* (Fabr.)], cutworm [*Spodoptera litura* (Fabr.)], and the green peach aphid [*Myzus persicae* (Sulzer)]. Two leaf-feeding beetles were also found associated with the cabbage agroecosystem, but their populations were very low: flea beetle (*Psylliodes* sp.) and squash beetle [*Aulacophora indica* (Gmelin)]. Hymenopterous parasites and predators, such as black ants, sphecid, and braconid wasps were minimal. Tachinid flies (Tachinidae) parasitized cutworm larvae, while a single cabbage looper larva was parasitized by a braconid wasp, *Cotesia* sp. (Braconidae). Very few adults of this wasp, however, were collected in cabbage fields.

Species richness and DBM population was not correlated with yield. Soil nutrients, especially phosphorus, affected yield. There was a strong correlation between average cabbage yield (kg) and the amount of phosphorus in the soil ($r=0.92$). Moreover, results indicated that average cabbage yield was correlated with spider number.

Introduction

Our natural ecosystems are taken for granted yet their great expanses support human existence. Among others, they provide essential raw materials, renew soils and prevent erosion, shelter animals that pollinate our agricultural crops and control agricultural pests, clean our water and air, and help regulate climate. People usually ignore their protection in favor of short-term profits. Even Philippine national parks, a refuge of rare and endemic biodiversity are not exempt from exploitation. Due to rapid population growth, resources are consumed faster leading to unsustainable exploitation of ecosystems. Overexploitation, mismanagement and lack of management have resulted in ecosystem collapse with loss of one or more resources, including loss of biodiversity (BSC 1996).

Biodiversity characterizes the dynamic state of an ecosystem's health, on which human survival depends. Biodiversity refers to all species of plants, animals, and microorganisms existing and interacting within an ecosystem (McNelly et al 1990). At its simplest, biodiversity measures the number and variety of species in an ecosystem. At a deeper level, it denotes genetic diversity that contributes to the population dynamics of species and provides a measure of their richness and interdependence. Biodiversity influences processes such as carbon and nutrient cycling, control of microclimate, regulation of hydrological processes, regulation of abundance of undesirable organisms, and detoxification of noxious chemicals (ESA 2000). These renewal processes and functions are largely biological; therefore, their persistence depends upon maintenance of biological diversity. When these natural functions are lost due to biological simplification, the economic and environmental costs can be quite significant (Altieri 1994).

Biodiversity-related issues, which include the greenhouse effect, global warming, ozone depletion, desertification, land use and appointment, surface and underground water contamination, and food safety are rapidly approaching crisis status. Although many environmental processes are beyond human control, our planet's long-term well-being depends on a solid understanding of how biological diversity functions to maintain a healthy planet.

Knowledge of biodiversity is important for wise management and use of resources. Managing biological diversity in a sustainable manner is the key challenge now faced by human societies (Hawksworth and Ritchie 1993) including the Philippines, which is considered a "hot spot" of biodiversity in the world (RAWOO 1998). One approach in conserving biodiversity especially in developing countries is through community-based stewardship, where local villagers are given larger roles in deciding how to manage their declining biodiversity (Morrell 1999). Conservationists are increasingly looking at this kind of participatory approach to save much of earth's threatened biodiversity.

Inventories of Philippine plants and vertebrates are still incomplete in terms of biodiversity information, but these are way ahead of and more updated than those of invertebrates, particularly arthropods, despite the fact that arthropods comprise 70% of the animal kingdom. The latest literature-based inventory of Philippine insects (Baltazar and Gapud 1995) recorded 20,131 species in 6,162 genera under 495 families and 27 orders. This number comes close to the earlier estimate of 25,000 for the Philippines (Baltazar 1990). Insects and their allies are the most diverse group of organisms in most ecosystems. As indicator species, they can provide a highly sensitive advance warning of ecosystem changes (Holloway and Stork 1991). They are bioindicators of habitat disturbances, pollution, and climate change (Hawksworth and Ritchie 1993). Their assessment, therefore, would provide detailed information on the status of Mt. Malindang's ecosystems, complementing information that will be obtained with other organisms.

Vegetables are the major sources of income and

Rationale

are one of the components of the diets of the rural population in the uplands of Mt. Malindang. Insect pests are regarded as one of the significant factors limiting vegetable yield. Although several control measures are available, the most convenient method employed by farmers is the use of pesticides.

Pesticides kill and injure a variety of organisms including insect pests and nontarget organisms such as wildlife, pollinators, natural enemies, and decomposer organisms. They significantly affect the highly diverse community of soil microorganisms and invertebrates that regulate nutrient cycling in ecosystems. Through drift and runoffs their impact can extend beyond the farms, affecting biodiversity of life in freshwater and marine ecosystems (Matson et al 1997).

The dependency of upland vegetable growers on pesticides therefore poses a threat not only to people but also to the ecosystem, which may lead to less biodiversity. Alternative methods to control insect pests must be studied to prevent the loss of biodiversity in the agricultural and surrounding natural ecosystems of Mt. Malindang due to continued pesticide use.

The first step toward developing economical programs for pest control is to properly identify the pests and associated beneficial species that provide natural control. Observation, experiment, and experience oftentimes show that in any ecosystem, only a few pests are economically important and some natural enemies can control them (FAO 1983). Assessing the presence of insects and other economically important arthropods associated with vegetables grown in the uplands of Mt. Malindang is therefore vitally needed in response to insect pest problems in the communities. Through the assessment, the roles of various insects and related arthropods can be established, leading to possible solutions to pest problems and preservation of biodiversity.

Objectives

A. Overall

To assess the diversity of insects and other economically important arthropods in the upland vegetable-growing areas in Mt. Malindang.

B. Specific

1. To assess and identify the major insect pests attacking cabbage;
2. To identify the natural enemies of insect pests attacking cabbage;
3. To identify other economically important arthropods found in the cabbage agroecosystem;
4. To assess arthropod diversity and community structures in the cabbage agroecosystem; and
5. To compare arthropod abundance among the different cabbage farms and relate it to farmers' cultural practices and other factors that may affect cabbage production.

The biological diversity of the world is unbelievably great. The visible "biota" (vascular and vertebrates)

Review of Literature

comprise between 2% to 6% of the estimated global biodiversity. Invertebrates including arthropods (insects, mites, spiders, and relatives), and the microflora and microfauna (bacteria, algae, fungi, protozoa, etc.) account for about 95% of biodiversity, and collectively form the “invisible” infrastructure that drives ecosystem dynamics (Hawksworth and Mound 1991, Hammond 1992).

Importance of arthropods in ecosystems

Arthropods constitute about 64% of the known global biodiversity. They are the most diverse group of organisms in most ecosystems. Their species richness vastly exceeds that of vascular plants and vertebrates together, while their biomass within natural ecosystems exceeds that of vertebrates (Lauenroth and Milchunas 1992, Wilson 1987). They are part of the meso and macrofauna and comprise elaborated food webs containing several tropic levels. Some feed directly on roots of living plants, but most subsist on dead plant matter and the microbes associated with it. Others are carnivores, parasites, or predators.

Arthropods represent a vast resource of ecosystem information that is currently underused. For instance, arthropods can provide information virtually on all macro and microhabitats within an ecosystem. They cover several size classes, exhibit a range of ecosystem requirements (highly specific to generalist) and dispersal abilities, show a variety of life cycle and development times, assist in mediating ecosystem functions such as decomposition, help maintain soil structure and soil fertility, regulate populations of other organisms (including arthropods, vertebrates, and plants), respond quickly to environmental changes, and act as “mobile links” essential to the reproduction of many flowering plants (Danks 1992, Kremen et al 1993, Wiggins et al 1991). Information derived from arthropod species assemblages can be used to accurately characterize almost any aspect of an ecosystem.

The use of arthropods as an indicator species can provide a highly sensitive advance warning of ecosystem changes (Holloway and Stork 1991). Some species react quickly to environmental stressors and are ideally suited to act as bioindicators of habitat disturbance, pollution, and climate change (Hawksworth and Ritchie 1993). Arthropods are routinely used in aquatic ecosystems to provide information on environmental quality. The advantage of using arthropod species as indicators or candidates for ecosystem monitoring is that their tremendous ecological diversity provides a wide choice for designing appropriate assessment programs (Kremen et al 1993), which can be applied for both short- and long-term monitoring. The use of arthropods in ecosystem analysis is cost effective. Arthropods are easily, quickly, and cheaply available, thus providing a means to obtain timely and cost-effective ecosystem information. Detailed sampling protocols exist for virtually all groups of arthropods in habitats ranging from derived soils in forest canopies to deep groundwater fauna (Marshall et al 1994). Identifying arthropod species generally is not as problematic as identifying fungi or bacteria, where DNA analysis and fatty acid profiles must often be employed (BSC 1996).

Arthropods are ideal for monitoring suitable effects associated with habitat fragmentation. Fragmented ecosystems subdivide populations and impose barriers to dispersal. These barriers limit gene flow and preclude migration as a response to environmental change (Ledig 1992). Fragmented populations contain only a part of the original gene pool and often are subject to substantial genetic drift and loss of genetic biodiversity (Brown 1992). Geographically circumscribed species with little genetic diversity have proven highly prone to extinction (Ehrlich 1992). Genetic diversity of arthropod populations in fragmented ecosystems can be measured and the rate of genetic drift assessed with respect to nonfragmented populations. In this way, an advance warning of ecosystem changes due to fragmentation, policy and management practices can be modified to reduce its impact (BSC 1996).

Fossil remains demonstrate that arthropod species are robust over long periods and that given the opportunity, they migrate with changing conditions rather than evolve new species. Arthropods are useful in reconstructing paleoenvironments because they are able to provide detailed and precise information on vegetation, soil, water quality, vertebrate species composition, forest composition, and degree of stress (Elias 1994). Shifts of fossil arthropod species derived from existing ecosystems are used to place fossils of the same species in ecological perspective and to reconstruct past environments. Shifts of fossil arthropod species assemblages can be used to assess biotic shifts resulting from environmental stressors or long climate change, because ecosystem data can be adjusted to account for recent arthropogenic changes. Such a long-term perspective is necessary to meaningfully assess ecosystem-wide biotic shifts. These assessments allow proactive development of policy on mineral fertilization, which can enhance epegeic arthropods through a rich supply of saprophagous mesofauna. The higher fertilization input in conventional fields leads to a higher crop density, which can alter the microclimate and also reduce the occurrence of helio- and thermophilous species (Pfiffner and Niggli 1996).

The physical, chemical, and biological characteristics of the soil are greatly influenced by the soil fauna. Silty-loam soils contain a richer fauna than sandy soils. Generally, the most important faunal groups are the arthropods (insects, mites, spiders, myriapods, springtails), the oligochaetes (earthworms and enchytraeids), nematodes, and mollusks (Pfiffner 2000).

Impact of agriculture on biodiversity

Agriculture, which involves about 25-30% of the world land area, is one of the main activities that affect biological diversity. One effect results from the fact that agriculture consists of simplifying the structure of the environment over vast areas, replacing nature's diversity with a few cultivated plants and domesticated animals. The world's agricultural landscapes are planted with only some 12 species of grain crops, 23 vegetable species, and about 35 fruit and nut crop species (Fowler and Mooney 1990).

Biodiversity simplification reaches an extreme in monocultures. Modern commercial agriculture is dominated by monoculture, and the reduced plant diversity influences the composition and abundance of associated biota such as wildlife, pollinators, insect pests and their natural enemies, soil invertebrates, and microorganisms (Matson et al 1997). The worsening insect problem is increasingly linked to expanding crop monocultures at the expense of the natural vegetation, thus decreasing local habitat diversity (Altieri and Letourneau 1982, Flint and Roberts 1988). Monocultures are often more vulnerable to pests and diseases and therefore require higher inputs of pesticides (Power and Flecker 1996).

Another way in which agriculture affects biodiversity is through the externalities associated with the use of intensive agrochemical and mechanical technology to boost crop production. In the US, about 17.8 million tons of fertilizers are used in grain production systems, and about 500 million pounds of pesticides are applied annually to farm lands. Although these inputs have boosted crop yield, their undesirable environmental effects are undermining the sustainability of agriculture (Altieri 1994). In the Philippines, pesticides are the main, if not the only control measure used on major vegetable crops such as cabbage, green beans, eggplant, and tomato (Sumalde 1995). In practical terms, pest and disease control in major vegetable-growing areas worldwide is synonymous with chemical control. World Resources Institute (WRI) et al (1992) identified five fundamental causes of biodiversity loss:

1. The unsustainably high rates of human population growth and natural resources consumption;
2. Economic systems and policies that fail to value the environment and its resources;
3. Inequity in the ownership, management, and flow of benefits from both the use and conservation of biological resources;
4. Deficiencies in knowledge and its application;
5. Legal and institutional systems that promote unsustainable exploitation.

The six mechanisms for biodiversity loss are habitat loss and fragmentation; introduced species; overexploitation of plant and animal species; pollution of soil, water, and atmosphere; global climate change; industrial agriculture and forestry.

The loss of biodiversity has a range of negative ecological and societal consequences. More immediately, loss of biodiversity can have significant impacts on ecosystem function within agroecosystems and economic returns from the cropping system. Conserving biodiversity thus provides several benefits to agriculture. Uncultivated species, including wild relatives of crops, are important sources of germplasm for developing new crops and cultivars. Natural areas adjacent to agricultural systems provide a habitat for pollinators and natural pest enemies. Within the agroecosystem itself, increasing crop diversity through polycultures can augment the resources available to pollinators and to natural enemies such as parasitic wasps, resulting in higher populations of these beneficial organisms (Andow 1991). Maximizing the use of agrochemicals can also result in preserving beneficial organisms and functional processes such as decomposition and nutrient cycling, thus, conserving biodiversity within the agroecosystem and enhancing plant and soil processes that in turn, improve crop productivity (Matson et al 1997).

Alternative methods of control other than chemical control are actively used in modern crop protection to develop ecologically and economically sound pest control procedures. The continued use of ecologically sound biological, cultural, and chemical methods is encouraged to preserve the quality of the ecosystem. Timing insecticide application and abandoning the fixed spray calendar can lead to substantial reduction in treatments and improvement of the pest-natural enemies situation (Gonzales 1976). If a key pest can be eradicated from a wide area, biodiversity may be enhanced by its absence due to reduced use of chemical pesticides (Thomas 1996).

Methodology

Sampling sites

The study sites planted with cabbage were located in the three barangays of Don Victoriano, Misamis Occidental, namely Nueva Vista, popularly known as Mansawan, Gandawan, and Lake Duminagat (Fig. 1). They were chosen mainly because of their distance from the primary forests of Mt. Malindang. The hypothesis was that the differing distance of these barangays from the forests would affect the level of arthropod biodiversity and insect pest infestation. It was assumed that the site nearest to the primary forest would have a higher level of biodiversity and lower insect pest infestation. Conversely, the farther the site was from the primary forest, the lower the biodiversity and pest infestation.

Sampling methods

Sampling was done in the middle of each farm measuring at least 60 m^2. Insects and related arthropods associated with cabbage were monitored weekly through sweep net, visual counts, and use of sticky and pitfall traps (Fig. 2).

A. Sweep net

Sweep net sampling was used for mobile insects. Twenty sweeps were made for each sampling. Arthropods collected were put into plastic bottles filled with ethanol and brought to the field house for sorting and identification. Twenty plants were selected from the 60-m^2 plot along a transect line chosen anew for each sampling occasion. Each cabbage plant was

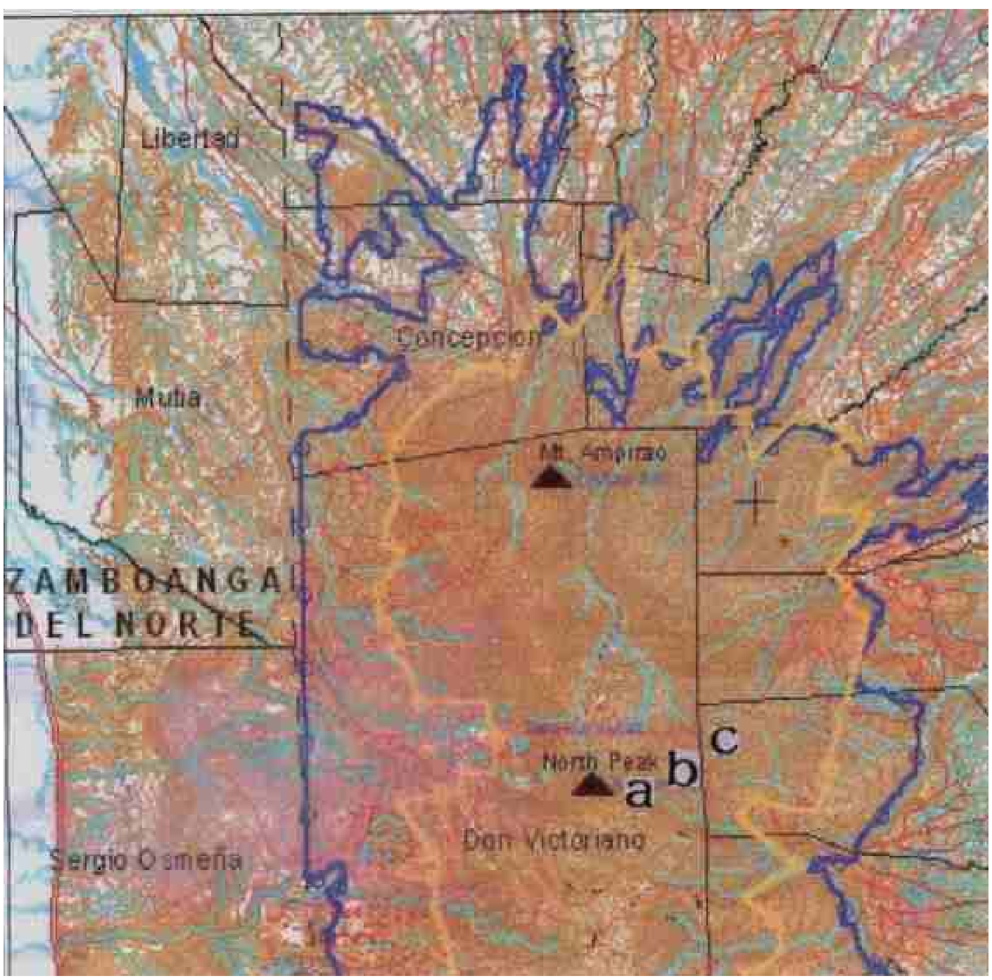


Fig. 1. Map showing location of three sampling sites in Mt. Malindang: (a) Lake Duminagat, (b) Gandawan, (c) Mansawan.

Fig. 2. Sampling methods: (a) sweep net, (b) visual count, (c) sticky trap, (d) pitfall trap.

examined for foliar insects such as the diamondback moth (DBM), cabbage semilooper, cabbage worm, cutworm, and aphids, together with associated arthropods like spiders. Counting and recording were done in the field by local partners under the supervision of the research assistant. Local partners were trained to identify common cabbage pests and natural enemies prior to the experiment.

Over 50 DBM larvae were collected weekly and reared on cabbage leaves under fieldhouse conditions. Undetermined numbers of secondary pest larvae were also reared to find out possible emergence of parasitoids. These pests were usually handpicked after visual counting in the field. Collecting and rearing larvae were done throughout the entire cabbage growing season. Observation was also done throughout the sampling period to determine promising predators of cabbage pests.

B. Traps

Two sticky traps, painted yellow, measuring 15 x 20 cm, were installed vertically and alternatively with pitfall traps inside the 60-m^2 sampling plot (Fig. 3). They were installed approximately 1 m above the ground to catch flying insects.

Fig. 3. Sticky and pitfall traps installed in study sites.

Insects and related arthropods that adhered to the traps were removed weekly using fine-pointed forceps and placed in vials filled with 80% ethyl alcohol for preservation and later identification. A transparent grease-based adhesive was applied on both sides of the traps after routine cleaning.

Pitfall traps made of plain galvanized iron sheet were sunk to the ground allowing the 12-in diameter lid to protrude a little to prevent rainwater from entering. The funnels were closely fitted to plastic containers half-filled with 70% ethyl alcohol. The traps collected ground-dwelling arthropods like springtails, scuds, and amphipods.

Arthropods collected through the different devices were sent to UP Los Baños for identification. Co-project Leader Dr. Stephen G. Reyes was responsible for the identification and statistical analysis of the data.

Biodiversity assessment of arthropods in cabbage farms

Ideally, identifying samples for ecological studies to species level is desirable. It is recognized that arthropod diversity is high and involves many specimens to be processed. In the Philippines, we have very few systematists that can handle specific taxonomic groups for identification. Therefore, in this study, identification to species level was limited to known and economically important taxa. Other taxonomic groups were identified to the family level; under each family, distinguishable morphospecies were assigned numbers, e.g., Tachnidae 1 for one distinguishable morphospecies of tachinid flies, and so on.

Since the project was participatory in nature, the interests of local partners were important, hence assessment was limited to the major pests of cabbage and possible natural enemies. These organisms were relatively common, easily detected, and sensitive to habitat disturbance and pesticide application, and importantly, have economic significance to the indigenous farmers of Mt. Malindang.

Participatory activities

Seven farmers in the three barangays of Don Victoriano, Misamis Occidental were tapped as local partners in the project.

The following activities were undertaken to encourage their participation:

1. Courtesy call and briefing on municipal and barangay officials about the project.
2. Identification of local partners through barangay officials.
3. Conduct of orientation meeting and lecture on pest identification.
4. Implementation of weekly sampling activities by local partners under the supervision of the project's research assistant.
5. Regular consultation with local partners and barangay officials.
6. Validation meeting.

Farming practices of selected local partners and their relevance to biodiversity

The farming practices of selected local partners were assessed and correlated to the agroecosystem of Mt. Malindang. It is hoped that this assessment would provide additional knowledge that would help enlighten the policymakers of Misamis Occidental so that they will formulate policies that would conserve Mt. Malindang's biodiversity.

Impact and constraints in implementing the project

The key impacts of the project and the major constraints in its implementation were assessed and are presented in this report. These results are expected to provide benchmark information and may serve as a guide for future biodiversity research projects to be implemented in the uplands of Mt. Malindang.

Results and Discussion

Sampling sites

Arthropods were assessed in cabbage fields of selected local partners in the three upland barangays of Don Victoriano, Misamis Occidental that included Nueva Vista, (Mansawan), Gandawan, and Lake Duminagat.

Mansawan is located near the town of Don Victoriano (10 km away), followed by Gandawan (17 km), while the farthest is Lake Duminagat. Cabbage fields of local partners varied in size (60-836 m^2) and slope (20-40°). Table 1 shows the salient features of the sampling sites including the pest management practices of local partners and their cabbage yield.

Local partners and description of their farms

Initially, three farmers were chosen as local partners for each barangay, but this was reduced to two (Mansawan and Gandawan). Infestation of cabbage rot disease due to frequent heavy rains prevented two farmers in participating in the project.

Thus, only seven farmers joined the research project as local partners:

Barangay	Local partners
1. Mansawan	Enerio Pacante Junnie Gumola
2. Gandawan	Roger Empil Danilo Empil
3. Lake Duminagat	Rudy Penalte Janito Tamon Carlos Gomistil

A. Mansawan

Two separate fields (A & B) were selected in barangay Mansawan. Field A is a 60-m^2 field managed by Mr. Enerio Pacante. The area was previously planted with onion for about three years, followed by sweet potato. It is fully exposed to sunlight throughout the day with a steepness of about 30°. The surrounding vegetation included some bananas, Malabago trees, avocado, and pomelo fruit trees, and vegetables like onion and pechay. The dominant vegetation, however, was *Saccharum* sp., a grass belonging to Graminae. The plot had 600 cabbage plants spaced 30-40 cm between rows and 25-37 cm between hills. Complete fertilizer (14-14-14) was applied six times during the season at varying levels with an interval of 9 days to 2 weeks after transplanting (WAT). Fertilizer was first dissolved in a specific amount of water (by gallons) and applied to individual plants. Each plant received approximately a ¼ can of sardine (155 g) fertilizer (by volume). Cabbage plants were sprayed seven times with *Ascend,* an insecticide, weekly starting from the first week of transplanting at the rate of one full cap of the insecticide (approximately 1 tbsp) mixed with water in a 16-L capacity sprayer tank. One sprayer tank loaded with the mixture was sprayed in the entire plot every spraying session.

Field B is a 150-m^2 pesticide-free area with approximately 1,500 cabbage plants managed by Mr. Junnie Gumola. Cabbage plants were spread with 40-60 cm between rows and 35-40 cm between hills. The area was planted previously with yam and exposed to sunlight for about 7 hours per day. The steepness of the slope was approximately 35°. The surrounding vegetation included tree ferns, some fruit trees such as marang and avocado, coffee, *Saccharum* sp., and some wild flowering shrubs. Complete fertilizer dissolved in water similar to Field A, was also applied to the plants.

B. Gandawan

Farm A, approximately 310 m^2, was managed by Mr. Roger Empil. For the previous three years, the area was planted to root and tuber crops like sweet potatoes, yam, and potatoes. The area has a 20° slope, receiving an average of 7 hours of sunlight per day. Vegetables such as onion and chayote surrounded the area along with some banana trees near the bottom. Mr. Empil applied the same kind of fertilizer, in the same frequency and manner of application, in his cabbage plants as Mr. Enerio and Mr. Gumola. No chemical was applied to control insect pests and diseases. Cabbage plants were spaced 40-50 cm between rows and 30-40 cm between hills.

The owner of Farm B was Mr. Danilo Empil, a brother of Mr. Roger Empil. Bamboos, tree ferns, bananas, chayote, and many *Saccharum* sp.

Table 1. Pest management practices, cabbage yield, and salient features of sampling sites. Don Victoriano, Misamis Occidental, Philippines.

Site / local partner	Pest management practice	Yield (kg / 20 heads)		Soil type	Soil pH	Steepness of slope	Planting density (m^2)	Planting distance (cm)		Duration of exposure to sun (no. of hours)	Land use for the previous three years	Surrounding vegetation
		Total	Mean					Per plant	Per row			
I. Mansawan												
E. Pacante	Sprayed**	1,844	0.092	clay	0.8	35°	13.33	25	30	8	Onion, sweet potato	Bananas, malabago tree, avocado, pomelo, onion, pechay, *Saccharum* sp.
J. Gumola	Unsprayed	7,850	0.390	loam	5.9	35°	7.14	35	40	7	Yam	Tree fern, wild shrubs, marang, avocado, coffee, *Saccharum* sp.
II. Gandawan												
R. Empil	Unsprayed	17,640	0.880	loam	5.9	20°	8.33	30	40	7	Yam, white potatoes, sweet potatoes	Onion, chayote, banana
D. Empil	Sprayed*	10,700	0.530	loam	5.5	30°	8.33	30	40	6	Uncultivated	Bamboos, tree ferns, bananas, *Saccharum* sp.
III. Lake Duminagat												
J. Tamon	Sprayed*	7,880	0.394	loam	5.8	20°	11.00	30	30	6	Uncultivated	
R. Penalte	Sprayed*	8,670	0.440	loam	5.6	20°	11.00	30	30	6	Uncultivated	Bamboos, tree ferns, bananas, *Saccharum* sp.
C. Gomistil	Unsprayed	7,680	0.384	loam	5.2	40°	16.00	25	25	2	Forested areas	Grasses, chayote, forest trees

Sprayed* = sprayed once
Sprayed** = sprayed seven times

surrounded his farm, which was about 285 m^2, with weeds in the upper part. It was exposed to sunlight for about 6 hours only during the afternoon since the area faced west. The area had a 30° slope. Like his brother, he also used complete fertilizer. However, he sprayed his cabbage plants with *Bushwack* at the rate of one full cap of the insecticide bottle (1 tbsp) mixed with water in a 16-L capacity knapsack sprayer.

C. Lake Duminagat

Farms A and B, approximately 836 m^2, were adjacent to each other and were managed by uncle and nephew farmers, Mr. Rudy Penalte and Janito Tamon. The area had been abandoned for five years before they took over and planted cabbage. Exposure to sunlight averaged 6 hours; the land had a 20° slope. Vegetation around the farms included tree ferns, bananas, chayote, yam, shrubs, grasses, and forest trees like tinagdong and pulayo.

Total cabbage density was approximately 7,500 with plants spaced 30-37 cm apart between rows and hills. Plants were side-dressed with complete fertilizer at 15-day intervals starting 2 weeks from transplanting and 2 weeks prior to harvesting. The approximate rate was one pinch per cabbage plant. *Magnum* (an insecticide) was sprayed once to control insect pests.

Mr. Carlos Gomistil managed Farm C, which was about 222 m^2 and with a 40° slope. It was the only farm that was part of the protected primary forest area. It was exposed to sunlight for about 2 hours per day only because of the presence of many tall trees with heights ranging from 15 to 25 m. Grasses and chayote likewise bordered the bottom part. Cabbage plants were spaced 25-30 cm between rows and between hills. Total plant density was around 2,500. Complete fertilizer was side-dressed (one pinch per plant). Weekly fertilizer application started 2 weeks after transplanting and ended 3 weeks prior to harvest.

Arthropods associated with cabbage

Arthropods constitute about 60% of known global biodiversity (Lauenroth and Milchunas 1992, Wilson 1987). They have evolved into the largest group of all living things in terms of number of species. They occupy many ecological niches, ranging from living on other arthropods, to eating either living or dead plants, or living in or on higher plants (Ross et al 1982).

Four classes of arthropods were found associated with cabbage grown in the uplands of Mt. Malindang. These included *Crustacea (*sowbugs and scuds*), Arachnida* (spiders and mites), *Diplopoda* (millipedes), and *Insecta* (insects). Among the arthropods, insects dominate in number and kind.

Class Crustacea

Sowbugs (*Isopoda*) are terrestrial crustaceans, which are closely related to lobsters, shrimps, and crayfish. They are active in the evening and run rapidly, superficially resembling cockroaches in form and behavior (Fig. 4a). Another group of terrestrial crustaceans, the scuds (*Amphipoda*) are pinkish to yellowish and shrimp-like in form (Fig. 4b).

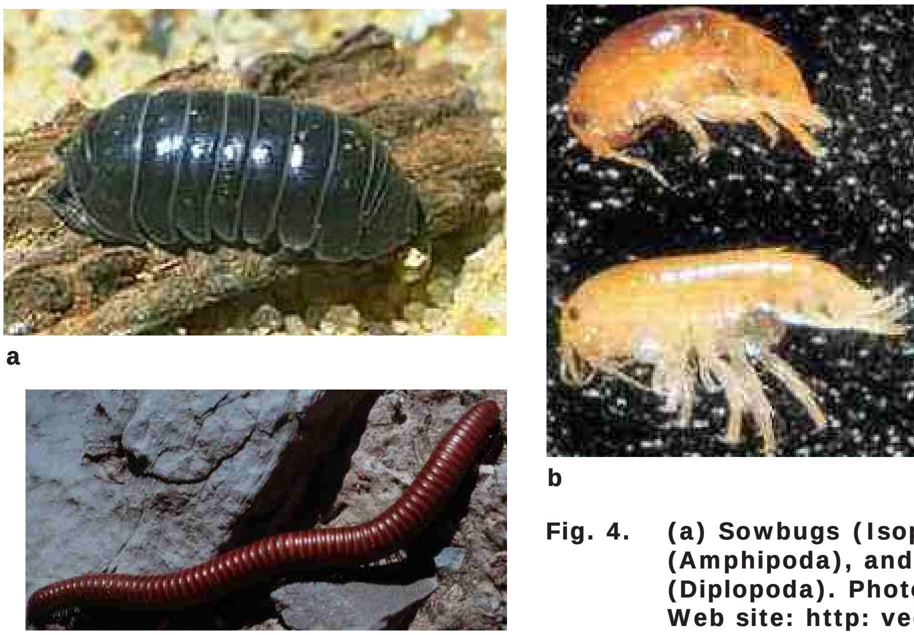
Sowbugs and scuds spend bright daylight hours in damp dark habitats such as underneath stones, logs, leaf litter, and other debris. At night they venture out and feed on decomposing organic material. They are mainly a nuisance and are capable of feeding on tender plant tissue and occasionally causing considerable damage to vegetable transplants and seedlings (Drees and Jackman 1999).

Class Diplopoda

This class of arthropods includes the millipedes or thousand-legged worms (Fig. 4c). Millipedes live in leaf litters, rotten logs, and humid places, with most species feeding on decaying plant materials (Ross et al 1982).

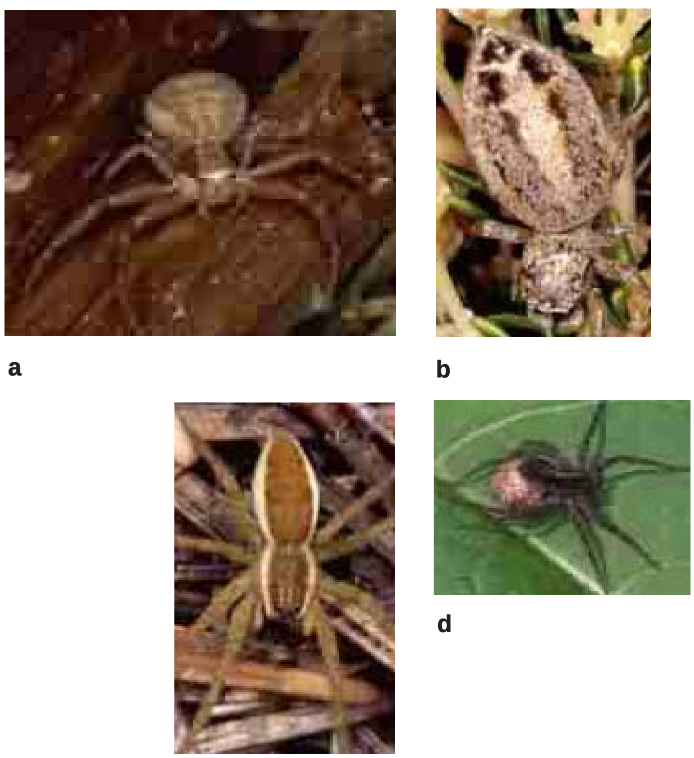
Class Arachnida

This class includes spiders and mites, which have several thousand species. Spiders are common and are the most important predators of insect pests in the uplands of Mt. Malindang. They are generalist predators and feed on many kinds of insect prey of suitable size. Some spiders will make webs to trap flying prey, while others hunt visually. Crab spiders, for example, wait in flowers or other places for the prey to come within reach (Fig. 5). Mites, on the other hand, include phytophagous, predatory, and detrivore species. Most phytophagous species are now recognized as important pests, while predatory mites are used in greenhouses to control pests such as thrips, aphids, and phytophagous mites.



a b c

Fig. 4. (a) Sowbugs (Isopoda), (b) scuds (Amphipoda), and (c) millipede (Diplopoda). Photographs from Web site: http: vegipm.tamu.edu, Extension Entomology, Department of Entomology, Texas A&M University.



a b c d

Fig. 5. (a) Crab spider, (b) jumping spider, (c) nursery web spider, and (d) wolf spider. Photographs from Web site: http:// vegipm.tamu.edu, Extension Entomology, Department of Entomology, Texas A&M University.

Class Insecta

Insects in the cabbage agroecosystem consist of 10 orders belonging to 60 families (Table 2). A common feature of many agroecosystems as exemplified in cabbage is a reduction in species richness coupled with high populations of other selected species (Stary and Pike 1999). Generally, the insect fauna associated with cabbage can be classified as phytophagous, predators, parasitoids, and neutrals.

A. Phytophagous insects

The four insect orders with pests are Lepidoptera (moths and butterflies), Homoptera (aphids), Coleoptera (beetles), and Orthoptera (grasshoppers) (Table 3). The diamondback moth or DBM (*Plutella xylostella*) is the major insect pest of cabbage. Visual counts done throughout the growth period of cabbage in the three study sites consistently showed a high population of DBM compared with other pest species.

Figure 6 shows the total number of DBM based on visual counts from sprayed and unsprayed cabbage farms. Higher larval populations were recorded on sprayed plots than on unsprayed ones. Results further showed that sprayed cabbage plots located far from the primary forests suffered heavy infestation of DBM compared with the unsprayed plot. As a result, the local partner who sprayed his cabbage plants seven times with an insecticide was not able to produce marketable heads.

Yellowish-white eggs of DBM are glued to the upper and lower leaf surfaces either singly or in groups. Larvae are pale yellowish-green to green covered with fine, scattered, erect hairs. They feed on leaves, which show the typical “window-type” damage (Fig. 7) caused by larval feeding of DBM. DBM larvae are easily identified by their peculiar reaction when disturbed. They actively wriggle and automatically hang themselves suspended by a silken thread. This “hanging” habit earned them their local name of “*bitay-bitay*”. Larvae pupate in delicate, white, open-mesh cocoons attached to the leaves of the host plant. Initially, the pupae are light green but as they mature, they become brown as the adult moth becomes visible through the cocoon. The adult moth can be identified by the three small white diamond-shaped marks that are visible when it is at rest with its folded wings (Fig. 8).

The minor pests of cabbage included the cabbage looper (*Trichoplusia ni*), cabbage worm (*Crocidolomia binotalis*), cutworm (*Spodoptera litura*), and the green peach aphid (*Myzus persicae*). Very few individuals of leaf-feeding beetles were observed to feed on cabbage like the flea beetle (*Psylliodes* sp.) and the squash beetle (*Aulacophora indica*).

The larvae of cabbage looper (*T. ni*) are light green and characteristically move in a “looping” manner. They are voracious feeders and strip foliage in a short time. Several kinds were observed in the cabbage fields, which included a brown species. Moths are light-grayish brown with a small lighter-colored spot near the center of each forewing (Fig. 9).

The larvae of cabbage worm (*C. binotalis*) are easily recognized by distinctive yellowish white stripes on their bodies (Fig. 10). Three stripes are located dorsally, while two stripes are on the lateral sides. These stripes disappear when larvae are close to pupation. Newly hatched larvae found on the underside of the leaves are gregarious; they then move to the growing point of the plant center or bore to the center of the head. A ravaged plant center with mats of frass and silk are evidence of cabbage worm damage (Fig. 11).

The cutworm *(S. litura*) is a common pest of corn, tomato, and vegetables. Eggs are laid on the underside of leaves in batches and are covered with hair scales from the body of the female moth. The newly hatched larvae at first stay in groups, but later disperse. Mature larvae are large, dark brown, and have pairs of black markings on the front and hind parts of the body. During the day these insects hide just beneath the soil close to the site of the previous night’s damage. They curl up into a tight C shape when disturbed. They pupate underground. Moths have brown wings with white markings (Fig. 12a).

The green peach aphid (*M. persicae*) is a polyphagous species with a large range of host plants, including cabbage. Aphids primarily feed on the sap of leaves and young shoots of plants. They withdraw nutrients from the plants and disturb the growth hormone balance, halting growth and causing the leaves to curl up. Through their enormous reproductive capability, they severely damage crops. They also have the ability to transmit viruses (Fig. 12b).

Table 2. Summary of classes, orders, and families of arthropods associated with cabbage grown in three barangays of Don Victoriano, Misamis Occidental. January-March, 2002. Specific details are given in Appendix Tables 1-4.

Class / Order	Family	Common name
A. Crustacea		
Isopoda		sowbugs
B. ARACHNIDA		
Acarina		mites
Araneae		spiders
C. MYRIAPODA		
Diplopoda		millipedes
D. HEXAPODA		
Collembola	Entomobryidae	springtails
E. INSECTA		
Orthoptera	Acrididae	katydids, crickets, grasshoppers
Gryllacrididae		
Gryllidae		
Tetrigidae		
Thysanoptera	Phlaeothripidae	thrips
Hemiptera	Cicadellidae	hoppers
	Cixiidae	
	Delphacidae	
	Flatidae	
	Fulgoridae	
	Membracidae	
	Nogodinidae	
	Tropiduchidae	
Coleoptera	Cerambycidae	beetles
	Chrysomelidae	
	Cleridae	
	Coccinellidae	
	Curculionidae	
	Elateridae	
	Languriidae	
	Lycidae	
	Scarabaeidae	
	Staphylinidae	
	Tenebrionidae	
Diptera	Anthomyiidae	true flies
	Cecidomyiidae	
	Chloropidae	
	Dolichopodidae	
	Drosophilidae	
	Empididae	
	Mycetophilidae	
	Muscidae	
	Neriidae	
	Otitidae	
	Phoridae	
	Rhagionidae	

Table 2. Continued...

Class / Order	Family	Common name
Diptera	Sepsidae	
	Sciaridae	
	Sciomyzidae	
	Stratiomyidae	
	Syrphidae	
	Tachinidae	
	Tipulidae	
Lepidoptera	Arctiidae	moths, butterflies
	Geometridae	
	Noctuidae	
	Pyralidae	
	Plutellidae	
Hymenoptera	Bethylidae	ants, wasps, bees
	Braconidae	
	Chalcididae	
	Formicidae	
	Ichneumonidae	
	Pompilidae	
	Sphecidae	
	Vespidae	

Table 3. List of economically important insect pests associated with cabbage grown in three barangays of Don Victoriano, Misamis Occidental. January–March, 2002.

Order/Family	Species	Common name
LEPIDOPTERA		
Plutellidae	*Plutella xylostella*	diamondback moth
Geometridae	*Trichoplusia ni*	cabbage looper
Pyralidae	*Crocidolomia pavonana*	cabbage worm
Noctuidae	*Spodoptera litura*	cutworm
Arctiidae	Unidentified sp.	tiger moth
COLEOPTERA		
Chrysomelidae	*Aulacophora indica*	squash beetle
	Psylliodes sp.	flea beetle
HEMIPTERA		
Aphididae	*Myzus persicae*	green peach aphid
ORTHOPTERA		
Acrididae	*Oxya* sp.	short-horned grasshopper

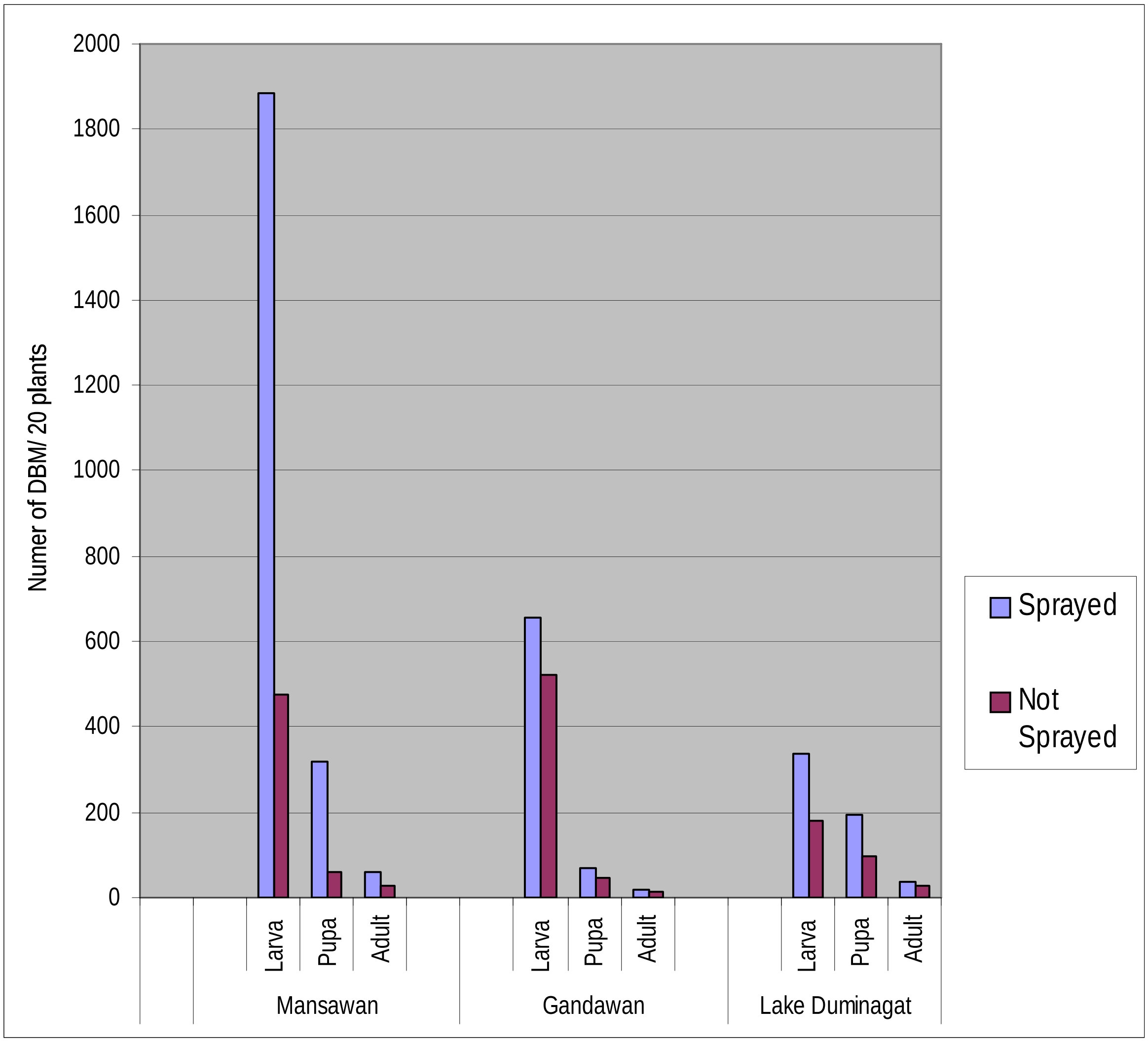


Fig. 6. **Total number of diamondback moths (*P. xylostella*) on sprayed and unsprayed cabbage plants estimated through visual counts in three barangays of Don Victoriano, Misamis Occidental. January-March 2002.**

a

b

Fig. 7. **(a) Typical window–type damage of DBM, (b) undamaged cabbage.**

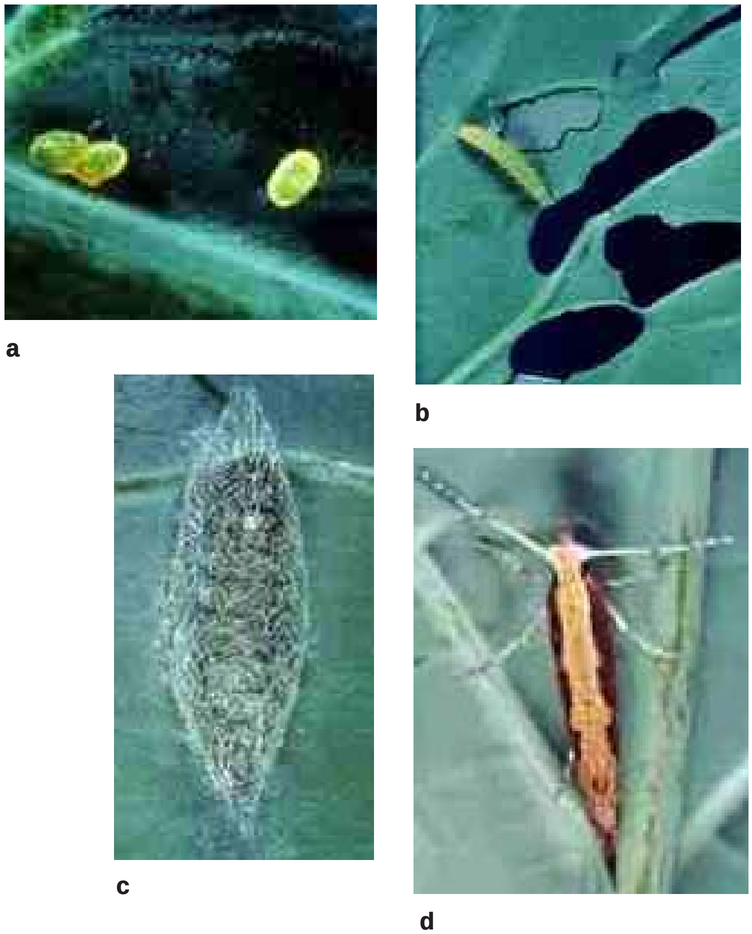


Fig. 8. **Life stages of the diamondback moth, *Plutella xylostella:* (a) eggs, (b) larva, (c) pupa, and (d) adult. Photographs from Web site: http://vegipm.tamu.edu, Extension Entomology, Department of Entomology, Texas A&M University.**

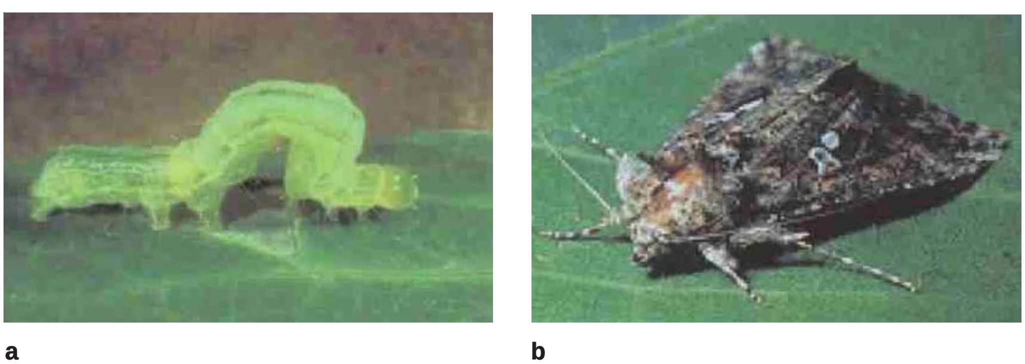
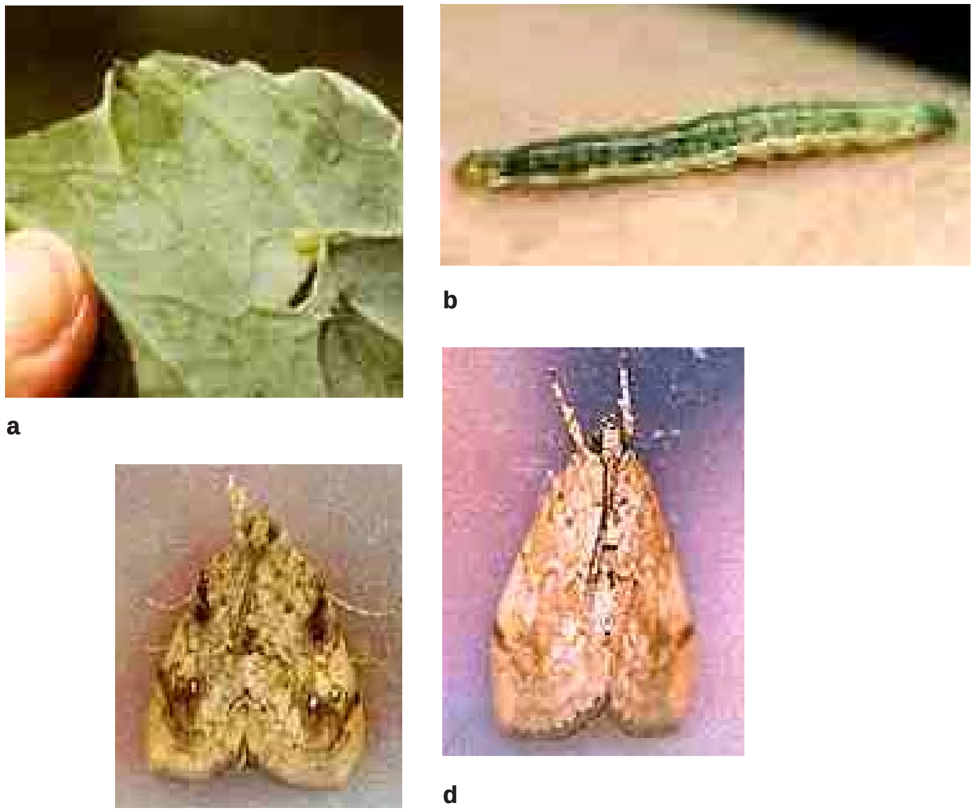


Fig. 9. **The cabbage looper, *Trichoplusia ni:* (a) larva and (b) adult. Photographs from Web site: http:vegipm.tamu.edu. Extension Entomology, Department of Entomology, Texas A&M University.**

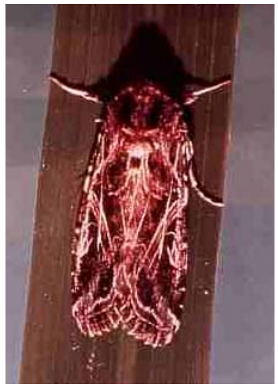


a b c d

Fig. 10. The cabbage worm, ***Crocidolomia pavonana:*** **(a) egg, (b) larva, (c) adult male, and (d) adult female. Photographs from Web site: http://vegipm.tamu.edu, Extension Entomology, Department of Entomology, Texas A&M University.**

a b

Fig. 11. Gregarious larvae of *C. pavonana* and their feeding damage. Photographs from Web site: http:// vegipm.tamu.edu, Extension Entomology, Department of Entomology, Texas A&M University.



a

b

Fig. 12. **(a) The adult cutworm, *Spodoptera litura* and (b) the green peach aphid, *Myzus persicae,* adult and nymphs. Photographs from Web site: http://vegipm.tamu.edu, Extension Entomology, Department of Entomology, Texas A&M University.**

Two leaf-feeding beetles were also found in cabbage farms but their populations were very low. These were the flea beetles (*Psylliodes* sp.) (Fig. 13) and the squash beetle (*A. similis).* Flea beetles are so named because of their enlarged hind legs and jumping ability. Adults are usually black, with brown legs and antennae. Eggs are laid in the soil at the base of the plants. From the eggs hatch cylindrical, brown-headed, white larvae that are about half an inch long when full grown. Round holes in leaves are the most obvious damage caused by flea beetles.

a

b

Fig. 13. Adults of the flea beetle, *Psylliodes* sp. Photographs from Web site: http://vegipm.tamu.edu, Extension Entomology, Department of Entomology, Texas A&M University.

B. Beneficial insects

Beneficial insects associated with insect pests of cabbage included parasites and predators. Several predatory species of Hymenoptera like black ants (Fig. 14a) and a vespid wasp (Fig. 14b) were observed feeding on live DBM larvae. The larva and adult of ladybird beetles (Coccinellidae) (Fig. 15) and hover flies (Syrphidae) fed on aphids. The population of these predators, however, was very low. Unlike the predators that kill more than one prey during their lifetime, parasitoids kill only one prey during their development and the adult is free living. Insect parasitoids lay their eggs in or on the host. The larvae that feed within or on the host kill it during their development. When fully grown, parasitoid larvae pupate and later emerge as adults, which generally feed on plant pollen or nectar (van den Berg and Cock 2000).

a b

Fig. 14. (a) Black ants feeding on a pink bollworm larva and (b) *Polistes* sp., a vespid wasp. Photographs from Web site: http://vegipm.tamu.edu, Extension Entomology, Department of Entomology, Texas A&M University.

a b

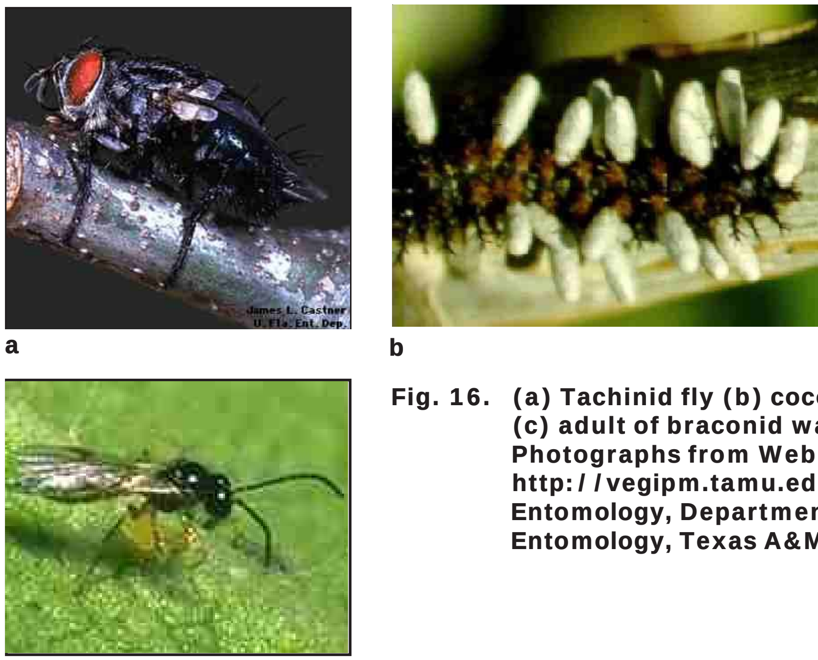
Fig. 15. (a) The predatory ladybird larva and (b) adult. Photographs from Web site: http://vegipm.tamu.edu, Extension Entomology, Department of Entomology, Texas A&M University.

Like the predators, the population of parasitoids in cabbage farms was very low. Not a single parasitoid was found parasitizing DBM larvae. Tachinid flies parasitized several cutworm larvae, while a single larva of cabbage looper was parasitized by *Cotesia* sp. (Braconidae) (Fig. 16).

Neutral insects consisted mainly of various flies, gnats, termites, collembolans, and their relatives (sowbugs, scuds, and millipedes). Majority of these insects are considered as detrivores.

Insect community structure in cabbage agroecosystem

Biological diversity and ecological guilds tend to be much lower in man-altered systems such as monocultural agricultural systems (Liss et al 1986), e.g., the cabbage agroecosystem. Habitat duration tends to be much shorter and ecological niches limited. It follows as well that guild interactions are limited and perhaps tractable. Individual species may have an important organizing influence in communities especially when resources are limiting. The DBM is considered a major pest of cabbage that limit production and reduces yield. In the context of community ecology, the DBM can be considered as an organizer species (Price 1971), with a major effect on the populations of other insect species in the vegetable agroecosystem. The use of pesticides to control its population may have important ramifications on the arthropod community structure and guild interactions. Furthermore, changing dominance structure due to interspecific competition with or without DBM is a potent organizing force, although some may claim that the test for the competition hypothesis is inadequate (Polis et al 1989, Price 1984). Predators and parasites may also play



a

b

c

Fig. 16. (a) Tachinid fly (b) cocoons, and (c) adult of braconid wasp, *Cotesia* sp. Photographs from Web site: http://vegipm.tamu.edu, Extension Entomology, Department of Entomology, Texas A&M University.

an organizing role in communities by keeping populations of herbivores, including DBM, below levels at which resources may become limiting (Lawton 1983). Besides these antagonistic interactions, mutualistic, commensalistic, and amensalistic interactions among species should also be considered (Price 1984). Additionally, species number and relative abundance, kinds of species present or absent, and the complex interactions existing among the components of the community should also be given importance to get a better view of the community dynamics and changing structure. In this study, we tried to assess the impact of farmers' insect control practices on the insect community structure in three cabbage farm sites with different proximity to the natural forest habitat.

Diversity of insect communities in three cabbage farms

Several diversity statistics describe the insect communities in any ecosystem although these measures differ in their discriminant ability depending on the type of habitats and sample size (see Magurran 1988). The Margaleff's index was used to look at insect diversity in the cabbage agroecosystem because it is relatively easy to calculate, it is highly sensitive to sample size, and it has good discriminant ability.

An analysis of variance (ANOVA) was performed to test whether species richness values were statistically different among the three treatments (sprayed, unsprayed, and a farm near the forest) in three sites. For the different sampling dates, species richness values among the treatments in the three sites were not significantly different at 5% level of significance ($F_{c0.84}$ = 19.48, α-level = 0.05). Similarly, species richness values among the sites were not significantly different ($F_{c1.57}$ = 19.48, α-level = 0.05). These results suggest that, in terms of relative abundance for the different treatments and sites, all species are relatively similar. Figure 17 shows Margaleff's indices for the different treatments and sites.

In the preceding discussion, species richness measure (Margaleff's index) was used to gauge the effect of pesticide use on cabbage. Generally, it is assumed that in a stressed environment, species richness would decrease. Other indicators of a stressed environment include the shift in the log normal pattern of species abundance and dominance (Magurran 1988). Basically, this study showed that in terms of species richness alone, there are no differences between the insect fauna of the different sites and treatments. However, species richness measures alone are an inadequate yardstick to track changes in community structure.

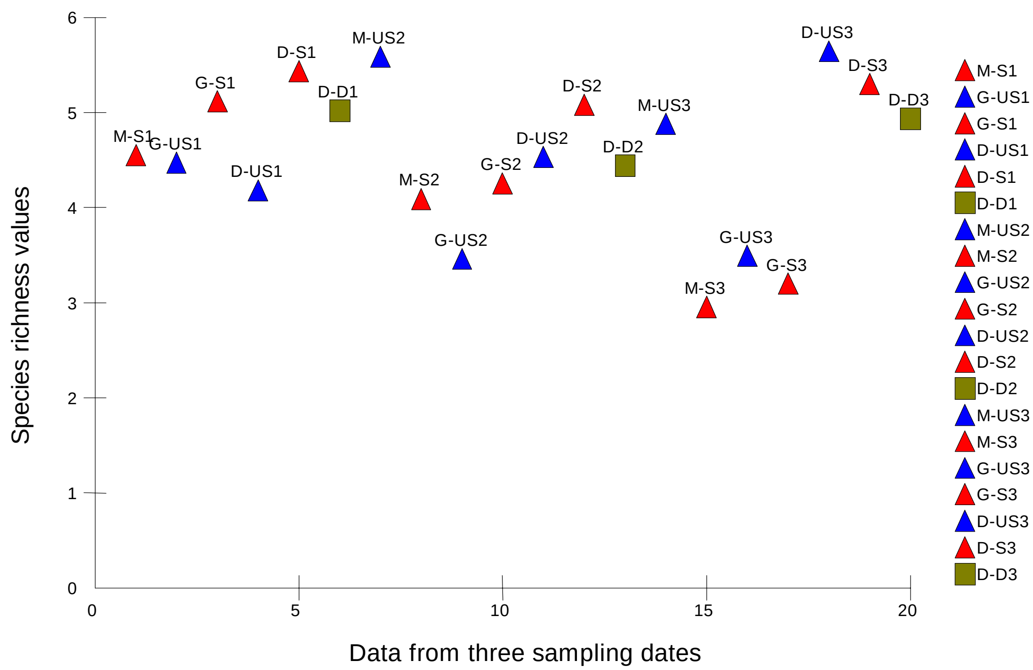


Fig. 17. Margaleff's indices for the different treatments and sites. The first letter denotes the site, e.g., M for Mansawan; US, S, and D mean unsprayed, sprayed, and near the forest; the number specifies the sampling date, e.g., 1 means the first sampling date. Data are from the first three sampling dates. Data points are not significantly different for treatments and sites. Data from the fourth to tenth sampling dates did not significantly differ for treatments and sites. Margaleff's indices were computed using McAleece (1997) BioDiversity Prof. Beta 1 ver.

Another tool that can graphically show possible differences in insect community structure is correspondence analysis. This is a type of ordination specifically designed for ecological studies and uses reciprocal averaging to determine axis values (Hill 1973). It is a powerful descriptive method, which can show correlation between biodiversity patterns and environmental causes of variation. As Figure 18 shows, most samples from different sites and treatments cluster near each other with very minimal exceptions. This further supports the findings that diversity for the different sites and treatments are not significantly different from each other.

Diversity of vegetation within and around the agroecosystem is one of the factors that can affect the degree of arthropod biodiversity. A greater variety of plants would lead to a greater variety of herbivorous insect species, and in turn determine a greater diversity of predators and parasites (Altieri 1984). This factor may account for the similarities in insect fauna of the different sampling sites and treatments. Generally, the surrounding vegetation of the sampling sites was less diverse and the composition was similar. This vegetation included tree ferns, a grass weed—*Saccharum* sp.—several bananas and fruit trees, and various wild shrubs (Fig. 19).

Guilds or functional groups in the cabbage agroecosystem

More diverse ecosystems tend to be more stable, resilient, and sustainable. In principle, the quality of diversity determines the extent to which it—in terms of varied guilds or functional groups—contributes to the stability and sustainability of the system (Peterson et al 1998). It is believed that the central role of guilds at the various trophic levels is more crucial than species diversity *per se* to the sustainability of the system. In the rice agroecosystem, for example, Heong et al (1991) showed that arthropod diversity contributes substantially to its sustainability.

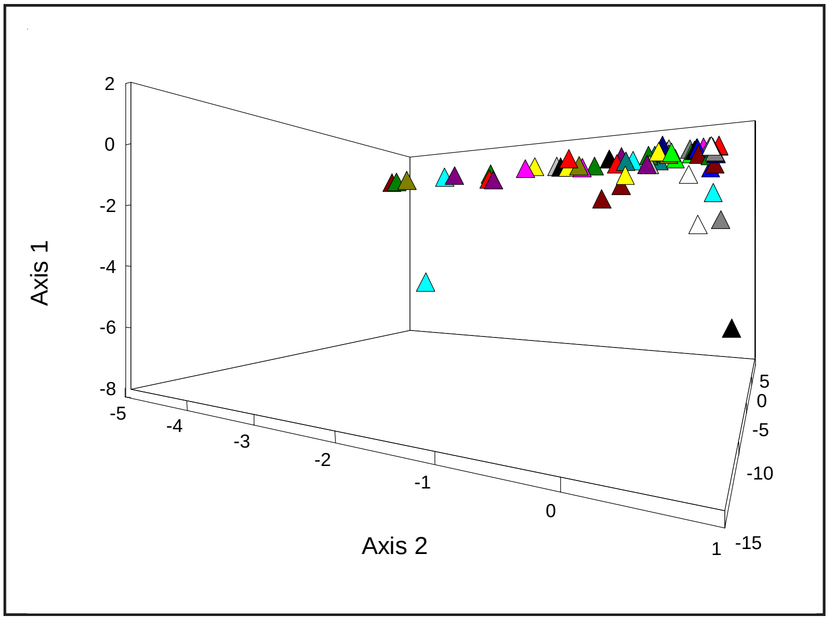


Fig. 18. Correspondence analysis performed with McAleece (1997) BioDiversity Prof. Beta 1 ver.

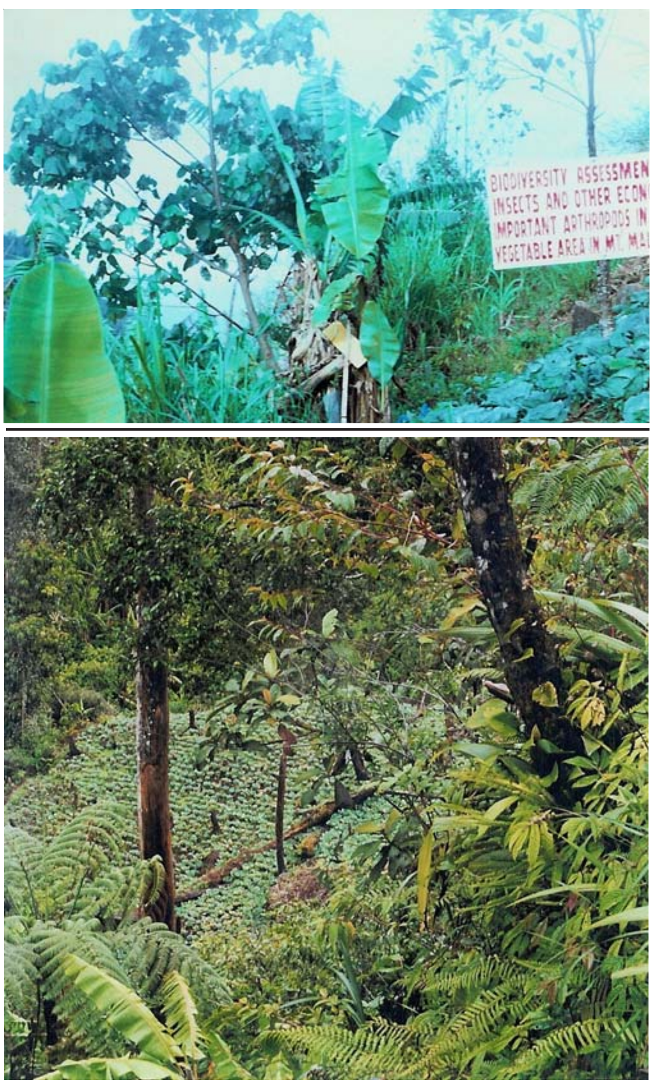


Fig. 19. Common vegetation surrounding the sampling sites.

The cabbage plant serves as a resource base for the insect communities and insect fauna are classified by specific guilds (functional groups), which include phytophagous insects, predators, parasitoids, and neutrals. Phytophagous species include DBM, cabbage looper, cabbage moth, cutworm, aphids, leafhoppers, and leaf-feeding beetles. Neutrals consist mainly of various flies, gnats and their relatives, sowbugs, millipedes, and termites–all are mostly detrivores. Predators and parasites are mainly hymenopterans.

In this study, we consider DBM as the organizer species. It was the most abundant and once it became established, the plant resource was mostly unavailable to other phytophagous species. For the different sites, DBM populations, however, were not significantly different ($F_{c1.80}$ = 8.59, α-level = 0.05) (Fig. 20). Similarly, DBM populations were not significantly different at 5% level of significance ($F_{c2.43}$ = 8.59, α-level = 0.05) (Fig. 21) for the different treatments. Hymenopterous parasites and predators were minimal. Spiders, on the other hand, were quite abundant and fed on DBM. Gandawan and Lake Duminagat had a significantly higher number of spiders than Mansawan ($F_{c8.98}$ = 8.59, α-level = 0.05) (Fig. 22). Spider populations were also significantly more abundant in the Lake Duminagat farm, which was near the forest ($F_{c29.71}$ = 8.59, α-level = 0.05) (Fig. 23) compared with the sprayed and unsprayed treatments. This abundance of spiders mostly exerted significant pressure on DBM populations. The prey-predator interaction between DBM and spiders is an important factor in community species structure and organization.

Several environmental factors may influence the diversity, abundance, and activity of parasitoids and predators in an agroecosystem. These include the availability of food (water, hosts, prey, pollen, and nectar), habitat requirements (refuges, nesting and reproduction sites), and the intensity of crop management. In many cases, weeds and other natural vegetation including flowering species act as insectary plants (Altieri 1984). Of the surrounding vegetation in the three sampling sites, only the grass weed *Saccharum* sp. produced inflorescence, which may provide pollen and nectar to parasitic insects such as *Cotesia* sp. Cocoons and a few adults of this parasitic wasp were found only in the cabbage farm of Mr. Danilo

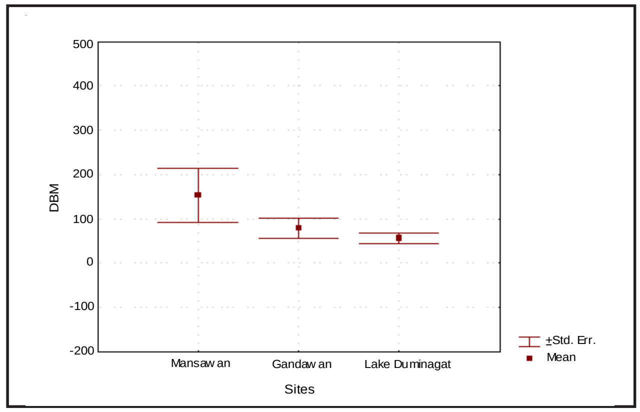


Fig. 20. DBM populations from different sites. Data points are not significant ($F_{c1.80}$ = 8.59, α-level = 0.05).

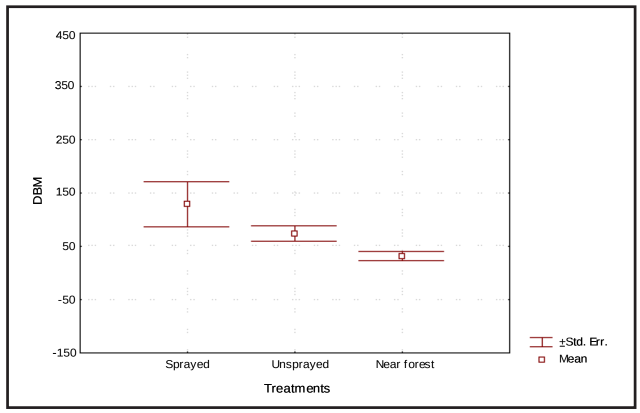


Fig. 21. DBM populations on different treatments. Data points are not significant ($F_{c2.43}$ = 8.59, α-level = 0.05).

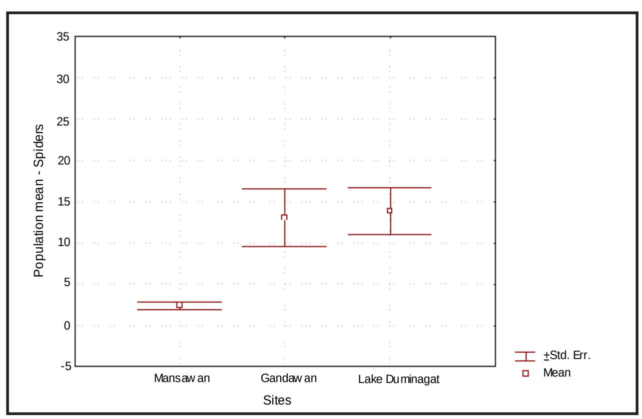


Fig.22. Spider populations from the different sites. Gandawan and Lake Duminagat sites have significantly higher spider populations compared with Mansawan ($F_{c8.98}$ = 8.59, α-level = 0.05).

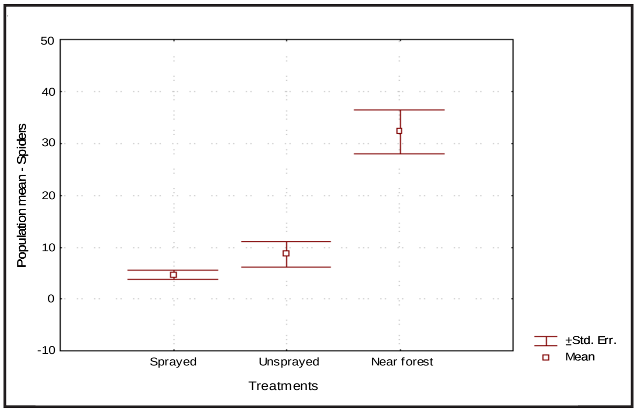


Fig. 23. Spider populations from different treatments. The farm in Lake Duminagat near the forest has a significantly higher number of spiders compared with the other farms ($F_{c29.71}$ = 8.59, α-level = 0.05).

Empil where *Saccharum* sp. abounded, unlike in the other sampling sites where there was not much of them. The abundance of this grass weed may explain the occurrence of the parasitic wasp in the said area.

The importance of nonhost or noncrop habitats as refuge for the natural enemies of insect pests particularly predators has been emphasized by some workers (Stachow and Knauer 1988). An adjacent forest perhaps served as refuge for the spiders thus explaining their abundance in a lone farm adjoining it in Lake Duminagat. Cabbage farms in Gandawan likewise were located near secondary forests, while no forest trees surrounded the farms in Mansawan.

The presence of trees therefore is a direct function of the abundance of spiders. Along with the trees come spiders that prey on pests attacking the nearby grown cabbage like the DBM. Altieri (1984) reported a considerable movement of entomophagous insects from woodlands into adjacent orchards. Barrion (1999) suggested that tall and rather compact plant stands provide a better environment and refuge for spiders in harsh times.

Correlation between yield, soil features, and arthropod diversity

One of the components supporting plant growth is soil nutrient. We had the soil samples from the different farms from the three sites analyzed for organic matter content, nitrogen (N), potassium (K), and phosphorus (P), and soil pH. The soil analysis was done in the Analytical Services Laboratory, Department of Soil Science, UP Los Baños. Table 4 summarizes the results.

We examined the relationship between yield and the amount of phosphorus in the topsoil because P is usually the limiting factor. As shown in Fig. 24, there is a strong correlation between yield and P (r = 0.92). The unsprayed plot in Gandawan showed a very high level of phosphorus followed by the sprayed and unsprayed farm in Lake Duminagat. This likely is the reason for the significant differences between sites and yield (Fig. 25) and also between treatments and yield (Fig. 26). There is no correlation between yield and species richness. Species richness, as measured by the Margaleff's index, is fairly uniform for all sites and treatments. Guilds or functional groups at the various trophic levels are probably more crucial than species diversity *per se* to the sustainability of the system. This is indicated by the significantly more abundant spider populations in Gandawan and Lake Duminagat and also in the farm near the forest. Additionally, there is also correlation with the number of spiders and yield, r = 0.66 (Fig. 27).

Table 4. Soil analysis results for the top 10-cm samples from three sites and different treatments.

Site	Treatment	pH	% Organic matter	% N	P ppm	K cmol(+) kg soil
Mansawan	sprayed	5.8	12.2	0.47	4	0.5
	unsprayed	6.3	43.6	0.96	11	1.9
Gandawan	sprayed	5.5	11.7	0.51	10	3.2
	unsprayed	5.7	70.8	2.34	90	0.8
Duminagat	sprayed	6.4	22.7	1.02	20	0.9
	unsprayed	6.0	36.0	1.28	18	1.1
	near forest	6.1	28.1	0.49	8	1.8

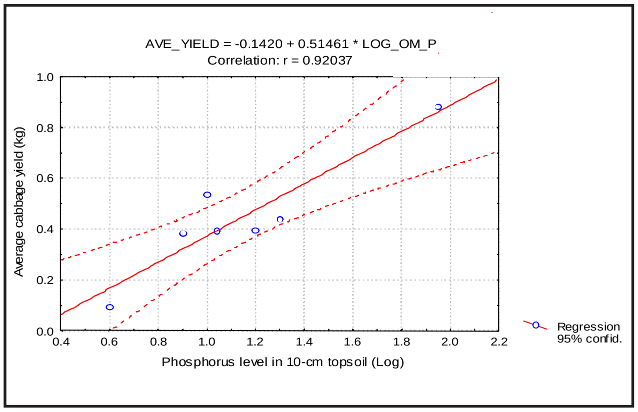


Fig. 24. Correlation between yield vs. phosphorus level. The two factors showed very high correlation, *r* = 0.92.

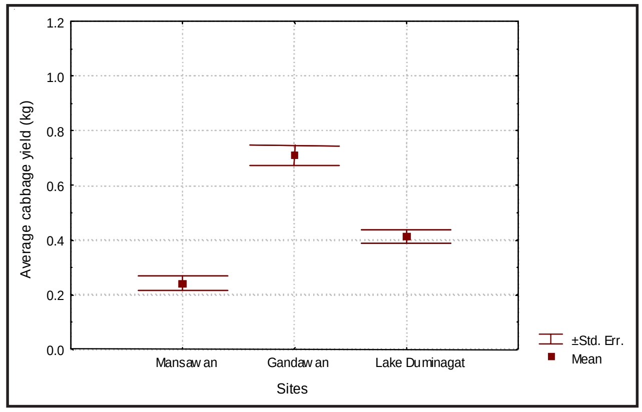


Fig. 25. Differences in yield among sites. Significant differences with Gandawan showing the highest average yield ($F_{c59.21}$ = 9. = 0. 48, α-level 05).

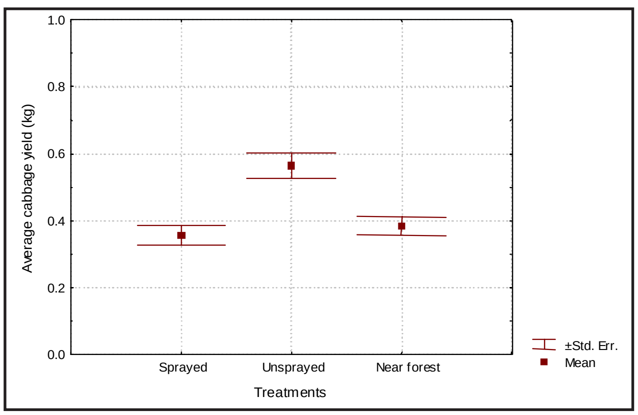


Fig. 26. Differences in yield among treatments. Significant differences with unsprayed plots showing the highest average yield ($F_{c11.55}$ = 9.48, α-level = 0.05).

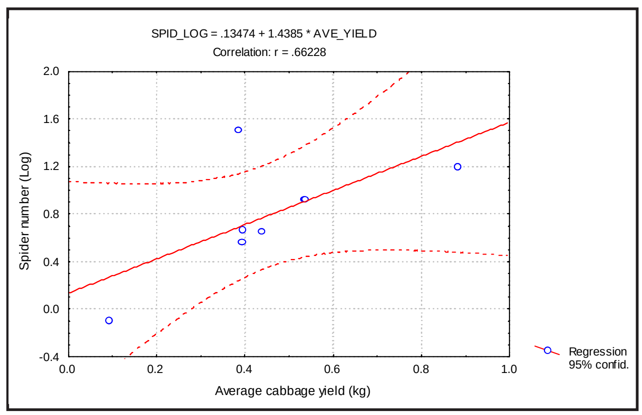


Fig. 27. Correlation between spiders and cabbage yield (in kg).

Participatory activities

Obtaining an entry permit from the office of the Mayor of Don Victoriano, Misamis Occidental, formally started the project. Mr. Alberto Cajeta, the municipal development officer, issued the permit, on behalf of the mayor. Local officials of the three barangays were all approached and consulted. Mr. Sergio Barimbao, the barangay captain of Nueva Vista, appointed Mr. Sonito Mangue, a councilor, to assist the lead researcher in identifying local partners from the three barangays. He provided valuable information and insights on the local people.

Local officials were completely briefed about the Biodiversity Research Project and SEARCA during the site visit. The research team lived in the village for the whole duration of the field work. On December 21, 2001 the team conducted a formal orientation meeting to brief local stakeholders about BRP, SEARCA, and the project. A lecture on pest identification including the natural enemies associated with cabbage pests was also done followed by field exercises on proper sampling and arthropod collection. Selected farmers were briefed on their responsibilities as local partners in the research project (Fig. 28).

At the end of the study, a validation meeting was conducted on October 11, 2002 at the Day Care Center of Nueva Vista, Don Victoriano, Misamis Occidental to present the findings of the project to local partners and selected barangay leaders. Likewise, researchers presented a research proposal for the next phase to get feedback from local partners.

Fig. 28. Pictures taken during the orientation meeting and lecture on pest identification held at Nueva Vista, Don Victoriano, Misamis Occidental on December 21, 2001.

Farming practices of selected local partners which may affect biodiversity (Researcher's view)

The current farming practices of selected local partners and their relevance to biodiversity were also assessed. Table 1 summarizes the pest management practices, actual yield of cabbage, and salient features of the sampling sites.

Only two of the seven local partners, the Empil brothers of Gandawan, were not Subanen. All the others were born in Mt. Malindang, but their parents were migrants from several municipalities in Misamis Occidental. Only a few finished elementary school education. These local partners earned their living by farming except for one who was partly working as a member of the Civilian Army Force Government Unit (CAFGU).

All of them used lands on steep slopes prone to erosion, and practiced shifting cultivation. They cleared lands to take advantage of the accumulated fertility but later abandoned them when pest infestation became high. Majority practiced monoculture, e.g., planting of cabbage, but one of them, Mr. Roger Empil, practiced multiple cropping, growing cabbage, chayote, onion, and taro (*gabi*). He did not plant cabbage continuously but grew another crop like onion in the area previously planted with cabbage to avoid DBM infestation.

Nearness to water supply, e.g., streams and ponds, was the main criterion used in selecting an area to be planted to cabbage and onion. Farmers usually dissolved the granular fertilizer 14-14-14 in water and applied one-fourth sardine can (155 g) of solution per plant. This practice is very laborious, since they have to apply the dissolved fertilizer on crops planted on steep slopes. Majority of the local partners applied fertilizers weekly, which usually started 2 weeks after transplanting, and ended 2 weeks prior to harvest. This practice is uneconomical and unsustainable at the same time. Figure 29 shows the "burnt" effect caused by fertilizers when applied at a high rate 2 weeks before harvest.

Many of the local partners cannot afford to buy chemicals to control pests and diseases. To solve this problem, they bought insecticides in retail. One bottle cap (approximately 1 tbsp or 10 mL) of *Bushwack* and *Magnum* costs P10.00, while Ascend costs P25.00. Three local partners sprayed their cabbage plants once with *Bushwack* and *Magnum*, while one sprayed *Ascend* seven times. The one who sprayed seven times obtained the lowest yield (0.09 kg/head), which was nonmarketable, while the one who obtained the highest yield (0.88 kg/head) did not spray at all. DBM population was very high, while spider counts were low on cabbage plants sprayed seven times. On the other hand, DBM population was low on unsprayed farms, while spiders were abundant particularly in the unsprayed farm that adjoined the forest.

It was learned during the validation meeting that underdosage was the main reason why the DBM population was not controlled in spite of frequent spraying. *Ascend*, whose active ingredient is Fipronil, is a pyrazole stomach/contact insecticide, used for controlling DBM in cabbage at 2-3.5 tbsps/16 L of water. It is applied as a high volume spray at a recommended rate of 20-tank loads/ha. Mr. Pacante applied one tank load for his 600-m^2 area at 1 tbsp/tank, which was below the recommended rate. The rate, however, seemed to be lethal to spiders because of their low population. The DBM population that infested Mr. Pacante's plants at the earlier stage came from the neighboring pechay (another crucifer), which is an alternate host of the pest. Cabbage plants were heavily damaged by the pest (Fig. 31), which resulted in great reduction in yield. Unsprayed cabbage plants did not suffer from high DBM infestation, resulting in high yield, primarily because they were planted in newly opened areas where the pest has not established yet. This was of course known by the local partners and was validated during the meeting. That is why most of the sample farms were located in remote and steep slopes, to evade DBM infestation.

Fig. 29. Burning effect caused by excessive fertilizer use.

Cabbage plants grown beside the forest did not suffer from high DBM infestation because of the presence of spiders that preyed on the pest. Yield, however, was lower than on other unsprayed farms mainly because of the very close planting distance, which led to competition for water, light, and nutrients. Moreover, the area was very steep (about 40°), thus much of the applied fertilizers were easily eroded and became unavailable to the plants.

In summary, these are the farming practices of the local partners and their relevance to biodiversity:

1. cultivation in steep slopes
   a. prone to erosion leading to fertility loss
   b. less diverse crops grown because of the steepness, therefore less biodiversity
2. shifting cultivation
   a. unsustainable; areas unable to regenerate because of short fallow period
   b. destroyed habitats of beneficial organisms
3. monoculture (e.g., cabbage)
   a. reduced species richness
   b. high population of selected species like the DBM
4. calendar application of fertilizers and pesticides
   a. affected biodiversity especially of natural enemies

Fig. 31. Cabbage plants heavily infested by the DBM, *P. xylostella.*

Key project impacts

Generally, the project generated a great deal of enthusiasm and interest among the local partners and also some local officials who attended the meetings conducted by the research team. Both the orientation and validation meetings were carried out in the local language, which facilitated understanding between researchers and local partners. The use of visual aids such as colored photographs of insect pests and their natural enemies greatly aided the lecture and promoted quick and better understanding among the participants.

Selected local partners gave local names of the common insect pests attacking cabbage and which were mainly derived from the pests' peculiar behavior or habit. For instance, they called DBM as *"bitay-bitay"* because of its habit of hanging itself when disturbed; cabbage worms as *"tapok-tapok"* because of their tendency to aggregate themselves; cabbage looper as *"dangaw-dangaw"* because the pest seems to measure when it moves; cutworm as *"utlob"* because it cuts; and aphids as *"pito-pito"* because they seem to stay always in groups of seven.

Weekly sampling of arthropods trained local partners to identify pests quickly and recognize the different stages of development, e.g., the larvae and pupae of the DBM. At the start of the project they found it difficult to recognize the minute eggs of the DBM, but after several sampling activities they became adept at it. Recognizing the different development stages gave them an idea of when to start controlling the pest, without our teaching them. For example, we noted that after counting the eggs of the DBM, a local partner would immediately crush them so that these eggs will not hatch into larvae. Larvae and pupae were also destroyed physically.

During the validation meeting, local partners were asked to cite the benefits they received from the project. The common answer was that they had learned to distinguish the pests from their natural enemies. This is important because farmers often think that all insects found on their crops are pests, hence these must be killed. Thus when the picture of black ants feeding on a larva of a certain pest was presented to them they agreed that indeed these ants were beneficial just like the spiders, and that these arthropods must be protected.

Innovativeness was seen as another impact of the project on local partners. Mr. Roger Empil of Gandawan, for instance asked if he could keep the insect net for himself after the project. He wanted to use the net to collect DBM adults and physically destroy them. His idea was greatly appreciated, but it was also explained to him that when he uses the net for collection, it is not only the pests that will be collected but also the natural enemies and neutral ones. The task of separating the pests from the nonpests would be laborious.

Constraints to project success

A. Low remuneration rate

Misconceptions about the nature of the project were seen as an important constraint in its implementation. Majority of the local partners had a "negative" perception about the project because they thought that it was going to be an "employment agency". One local partner kept complaining about the low rate of remuneration (P50.00), which he received for doing the sampling activities. His basis for comparison was the other BRP project which gave a higher rate (P160.00/day). We believed that the amount given to the local partners was fair enough because they only spent 2-3 hours in sampling, while the collaborators of the other project spent the whole day doing their responsibilities. Giving remuneration to local partners is considered a hindrance in implementing participatory research projects. Competition among local partners was observed during the validation meeting when they learned that there would be another research project. All of them wanted to become local partners again.

B. Problem on research personnel

Implementing the project was delayed because of some problems regarding the recruitment of a research assistant. Initially, the project identified Mr. Eliseo C. Mituda, the brother of the lead proponent for the position. His appointment, however, was questioned since BRP prohibits the appointment of close relatives of people involved in the project. An appeal was made to BRP-JPC to reconsider Mr. Mituda's appointment mainly because of safety considerations and concerns about family matters. The request was finally granted after almost two months, but in the end Mr. Mituda decided not to join the project anymore.

Mr. Ervin Dris, a BS Agronomy graduate of the Mindanao State University (MSU), Marawi City, got the position. He was responsible for contacting selected local partners and establishing rapport and harmonious relationships with them. He supervised the land preparation of the study sites including the sowing of cabbage seeds in the seedbed and constructing sampling devices for arthropod biodiversity assessment. He also helped in planning and implementing orientation meetings for local partners about BRP, SEARCA, and the research project. Simultaneous with the orientation meeting was a lecture and practical exercises on pest identification. He joined local partners in sampling for arthropods during the first three weeks. However, Mr. Dris decided to quit due to health reasons on January 16, 2002.

Mr. Esteban Padogdog, Jr., a graduate of BS Forestry of MSU replaced Mr. Dris. His experience and training as a forester from his previous jobs aided him in performing his responsibilities. Sampling activities were finished when the local partners finally harvested and sold the cabbage plants.

Summary and conclusion

Biodiversity of arthropods was assessed on cabbage fields of seven local partners in the three upland barangays of Don Victoriano, Misamis Occidental, including Nueva Vista, Gandawan, and Lake Duminagat. Cabbage fields varied in size (60-836 m^2) and slope (20-40º).

Four classes of arthropods were found associated with cabbage: Insecta (insects), Arachnida (spiders), Crustacea (sowbugs), and Diplopoda (millipedes). Insects dominated these arthropods comprising 10 orders belonging to 60 families. Various flies, gnats and their relatives, collembola, termites, sowbugs, and millipedes are mostly detrivores. The diamondback moth or DBM (*Plutella xylostella* Linn.) is the major pest of cabbage that limits production and reduces yield. Other insect pests observed included the cabbage looper (*Trichoplusia ni* Hubner), cabbage worm *(Crocidolomia binotalis),* cutworm (*Spodoptera litura),* and the green peach aphid (*Myzus persicae*). Two leaf-feeding beetles were also found associated with the cabbage agroecosystem but their population was very low. These were the flea beetles (*Psylliodes* sp.) and the squash beetle (*Aulacophora similis*). Hymenopterous parasites and predators were minimal and included the black ants, and sphecid and braconid wasps. Tachinid flies (Tachinidae) parasitized cutworm larvae, while a single cabbage looper larva was parasitized by a braconid wasp, *Cotesia* sp. (Braconidae). Very few adults of this wasp, however, were collected in cabbage fields.

The arthropod species diversity was also assessed for the seven cabbage farms from the three sites in Mt. Malindang. Species richness was measured using the Margaleff index, which was found not significantly different among treatments for the three sites. Correspondence analysis also showed general uniformity of species richness among sites and treatments. DBM is the dominant phytophagous species; DBM populations from the three sites and farms did not significantly differ. Spiders dominated the predatory guild with spider numbers significantly more abundant in Gandawan and Lake Duminagat. Among treatments, the farm near the forest harbored significantly more spiders than sprayed and unsprayed cabbage farms. Species richness and DBM population were not correlated with yield.

Soil nutrients, especially phosphorus, affect yield. A strong correlation was found between average cabbage yield (kg) and the amount of phosphorus in the soil (r = 0.92). Moreover, there is indication that average cabbage yield is correlated with spider number.

The weekly participatory sampling activities of arthropods built up the capability of local partners to quickly identify the different life stages of the major insect pests of cabbage including their natural enemies.

The farming practices of the selected local partners and their relevance to biodiversity included the following: (1) cultivation in steep slopes: prone to erosion leading to loss of fertility; less diverse crops due to steepness hence less biodiversity; (2) shifting cultivation: unsustainable and destroyed habitats of beneficial organisms; (3) monoculture: reduced species richness and population of selected species like the DBM; (4) calendar application of fertilizers and pesticides: affected biodiversity especially of natural enemies.

Recommendations

These recommendations are given to serve as a guide for policymakers, institutions, agencies, programs like the BRP, and interested individuals who are committed to promoting biodiversity conservation in Mt. Malindang.

Generally, there is an urgent need to formulate and implement policies that will result in the following:

1. practice of settled agriculture – farmers must have a sense of ownership to avoid practicing shifting cultivation;
2. promotion of agricultural practices that will conserve biodiversity such as minimal usage of chemical pesticides and fertilizers;
3. habitat diversification, e.g., crop rotation, intercropping, multiple cropping; and
4. empowerment of farmers through education and training.

It is apparent from the findings of this research that there is an urgent need to implement integrated pest management (IPM) to minimize pest problems in the uplands. Through IPM, farmers will be better equipped to make decisions that will manage pests effectively without full reliance on pesticides. It would also minimize problems in shifting cultivation, since farmers would no longer have to plant in newly opened areas to avoid pest damage. It would also pave the way for implementing integrated crop management (ICM) to help solve the complex problems in farming systems, e.g., correct fertilizer usage and proper weed control. There is also a need to study the diversity of spiders in the uplands of Mt. Malindang to maximize their potential in regulating populations of pests like the DBM.

Literature cited

Altieri, M.A. 1984. Patterns of insect diversity in monocultures and polycultures of brussel sprouts. Prot. Ecol. 6:227-232.

Altieri, M.A. 1994. Biodiversity and pest management in agroecosystem. Food Products Press. The Haworth Press, Inc., 10 Alice Street, Binghamton, NY.

Altieri, M.A. and D.K. Letourneau. 1982. Vegetation diversity and insect pest outbreaks. CRC, Critic. Rev. Plant Sci. 2:131-169.

Andow, D.A. 1991. Vegetational diversity and arthropods population response. Ann. Rev. Entomol. 36:561-586.

Baltazar, C.R. 1990. An inventory of Philippine insects. I. Orders Neuroptera, Strepsiptera, Siphonaptera, Trichoptera and Diptera. UPLB, University Publications Office, College, Laguna, Philippines. 703 p.

Baltazar, C.R. and V.P. Gapud. 1995. An inventory of Philippine insects. National Research Council of the Philippines, Terminal Report.

Barrion, A.T. 1999. Guild structure, diversity and relative abundance of spiders in selected nonrice habitats and irrigated rice fields in San Juan, Batangas, Philippines. Philipp. Ent. 13(2):129-157.

Biological Survey of Canada (BSC). 1996. The advantages of using arthropods in ecosystem management. January.

Brown, A.H.D. 1992. Human impact on gene pool and sampling for their conservation. Oikos 63:109-118.

Danks, H.V. 1992. Long life cycles in insects. Can. Ent. 124(1):167-187.

Drees, B.M. and J. Jackman. 1999. Field guide to Texas insects. Gulf Publishing Co., Houston, Texas.

Ehrlich, P.R. 1992. Population biology of chickenspot butterflies and the preservation of global biodiversity. Oikos 63:6-12.

Elias, S.A. 1994. Quaternary insects and their environments. Smithsonian Institution Press, Washington. 284 p.

Entomological Society of America (ESA). 2000. Position statement on insects and biodiversity. In: Insects as biodiversity indicators. 9301 Annapolis Road, Suite 3000 Lanham, MD.

Flint, M.L. and P.A. Roberts. 1988. Using crop diversity to manage pest problems: Some California examples. Am. J. Alternative Agric. 3:164-167.

Fowler, C. and P. Mooney. 1990. Food, politics and the loss of genetic diversity. The Univ. of Arizona Press, Tucson, A Z.

Gonzales, R.H. 1976. Crop protection in Latin America with special reference to integrated pest control. FAO PH Prot Bull. Vol. 24:3.

Hammond, P.M. 1992. Species inventory. In: B. Groombridge, editor, Global biodiversity: Status of the earth's living resources. Chapman and Hall, London. p.17-39.

Hawksworth, D.L. and J.M. Ritchie. 1993. Biodiversity and biosystematic priorities: microorganisms and invertebrates. CAB International Wallingford, UK. 70 p.

Hawksworth, D.L. and L.A. Mound. 1991. Biodiversity data-bases: The crucial significance of collections. In: D.L. Hawksworth, editor. The biodiversity of microorganisms and invertebrates: Its role in sustainable agriculture, CAB International, Wallingford, UK. 302 p.

Heong, J.L., G.B. Aquino, and A.T. Barrion. 1991. Arthropod community structures of rice ecosystems in the Philippines. Bull. Ent. Res. 81:407-416.

Hill, M.O. 1973. Reciprocal averaging: an eigenvector method of ordination. J. Ecol. 61:237-249.

Holloway, J.D. and N.E. Stork. 1991. The dimensions of biodiversity: The use of invertebrates as indicators of human impact. In: D.L. Hawksworth, editor. The biodiversity of microorganisms and invertebrates: its role in sustainable agriculture. CAB International, Wallingford, UK. 302 p.

Kremen, C., R.K. Colwell, T.C. Erwin, D.D. Murphy, R.F. Noss, and M.A. Sanjayan. 1993. Terrestrial arthropod assemblages: Their use in conservation planning. Conserv. Biol. 7(4):796- 808.

Lauenroth, W.K. and D.G. Milchunas. 1992. Shortgrass steppe. In: R.T. Coupland, editor. Natural grasslands introduction and Western hemisphere. Ecosystems of the World BA. Elsevier, Amsterdam. 469 p.

Lawton, J.H. 1983. Plant architecture and the diversity of phytophagous insects. Ann. Rev. Entomol. 28:23-39.

Ledig, F.T. 1992. Human impacts on genetic diversity in forest ecosystem. Oikos 63:87-108.

Liss, W.J., L.J. Gut, P.H. Westigard, and C.E. Warren. 1986. Perspective on arthropod community structure, organization, and development in agricultural crops. Ann. Rev. Entomol. 31:455-478.

Magurran, A. 1988. Ecological diversity and its measurement. Princeton University Press, x + 179 p.

Marshall, S.A., R.S. Anderson, R.E. Roughley, V. Behan-Pelletier, and H.V. Danks. 1994. Terrestrial arthropod biodiversity supplement. 33 p.

Matson, P.A., W.J. Parton, A.G. Power, and M.J. Swift. 1997. Agricultural intensification and ecosystem properties. Science 277:504-509.

McAleece, N. 1997. BioDiversity Professional Beta 1. The Museum of Natural History, London and The Scottish Association for Marine Science.

McNelly, S., B. Geier and S. Stalfon. 1990. The relationship between nature conservation, biodiversity and organic agriculture. The International Federation of Organic Agriculture Movement (IFOAM), Germany.

Morell, V. 1999. In search of solutions. National Geographic 195 (2): 72-87.

Peterson, G., C.R. Allen, and C.S. Holling. 1998. Ecological resilience, biodiversity, and scale. Ecosystem 1:6-18.

Pfiffner, L. 2000. Significance of organic farming for invertebrate diversity - enhancing beneficial organisms with field margins in combination with organic farming. Res. Inst. Org. Agriculture, Switzerland.

Pfiffner, L. and U. Niggli. 1996. Effects of bio-dynamic, organic and conventional farming on ground beetles and other epigaeic arthropods in winter wheat. Biol. Agric. and Hort. 12:353-364.

Philippines, Department of Environment and Natural Resources (DENR). 1977. Philippines biodiversity: An assessment and plan of Makati City. Bookmark.

Polis, G.A., C.A. Myers, and R.D. Holt. 1989. The ecology and evolution of intraguild predation: Potential competitors that eat each other. Ann. Rev. Ecol. Syst. 20:297-330.

Power, A.G. and A.S. Flecker. 1996. The role of biodiversity in tropical managed ecosystems. In: G.H. Orians, R. Dirzo, and J.H. Cushman, editors, Biodiversity and ecosystem process in tropical forests. Springer-Verlag, New York. p. 173-194.

Price, P.W. 1984. Alternative paradigms in community ecology. In*:* P.W. Price, C.N. Slobodchidoff, W.S. Gauld, editors. A new ecology: Novel approaches to interactive systems. John Wiley and Sons NY. 515 p.

Price, P.W. 1971. Niche breadth and dominance of parasitic insects sharing the same host species. Ecology 52:587-596.

Ross, H.H., C.A. Ross, and J.R.P. Ross. 1982. A textbook of entomology. John Wiley and Sons, Inc., Canada.

Statchow, U. and N. Knauer. 1998. The importance of hedges in an agroecosystem of Schleswig Holstein. II. Carabid beetles (Carabidae: Col). Z. Kultruiotech. Flurbereinig. 29:299-306. Cited in M.G. Padetti and D. Pimentel, editors. Biotic diversity in agroecosystems.

Sumalde, A.C. 1995. Environmental impact of pesticides and other concerns related to their use in vegetable production in the Philippines. In: E.D. Magallona, A.C. Sumalde, A.C. Pola, P. MacQuarrie, editors. Selected papers on pesticides management and regulation in the Philippines. Environment and Resource Management Project (ERMP), Philippines.

Sotherton,N.W. 1998. Land use changes and the decline of farmland wildlife: An appraisal of the set-aside approach. Biol. Conserv. 83:259-268.

The Netherlands Development Assistance Research Council (RAWOO). 1998. Framework for Philippine–Dutch Programs of Biodiversity Research for Development. Publication No. 17. The Hague, the Netherlands. 36 p.

Thomas, J.D. 1996. Using marine invertebrates to establish research and conservation priorities. In: M.L. Reaka, Kudla D. & E. Wilson, editors. Biodiversity II: understanding and protecting our biological resources. National Press.

van den Berg, H. and M.J.W. Cock. 2000. African oduom and its natural enemies in Kenya. CABI BioScience, CABI UK Centre (Ascot), Silwood Park, Buckhurst Road, Ascot, Berkshire, SL5 7TA, UK.

Wilson, E.A. 1987. The little things that run the world (The importance and conservation of invertebrates). Conserv. Biol. 1:344-346.

World Resources Institute (WRI), World Conservation Union (WCU), United Nations Environment Programme (UNEP). 1992. Global biodiversity strategy guidelines for action to save, study and use Earth's biotic wealth sustainably and equitably.

Appendix

Table 1. Visual counts of arthropods from Mt. Malindang.

Day 1				
M-S1	Enerio	01/08/02	Mansawan	
Plutella xylostella				68
Spiders				3
G-US1	Roger	01/08/02	Gandawan	
Plutella xylostella				46
Spodoptera litura				2
Spiders				19
Beetle				2
Leafhoppers				1
G-S1	Danilo	01/08/02	Gandawan	
Plutella xylostella				32
Spodoptera litura				1
Trichoplusia ni (larvae)				1
Spiders				4
Beetle				1
Leafhoppers				1
Hairy caterpillars				1
D-US1	Janito	01/17/02	Lake Duminagat	
Plutella xylostella				45
Myzus persicae				4
Crocidolomia binotalis				1
Grasshoppers				1
Spiders				3
D-S1	Rudy	01/17/02	Lake Duminagat	
Plutella xylostella				10
Myzus persicae				1
Spiders				19
Wasp				2
Ants				1
D-D1	Carlos	01/17/02	Lake Duminagat	
Plutella xylostella				3
Myzus persicae				1
Spiders				38
Snail				2
Day 2				
M-US2	Junnie	01/12/02	Mansawan	
Plutella xylostella				36
Spiders				3
Fly				1
M-S2	Enerio	01/12/02	Mansawan	
Plutella xylostella				102
Spiders				3
G-US2	Roger	01/15/02	Gandawan	
Plutella xylostella				205
Spodoptera litura				1

Trichoplusia ni (larvae)				14
Spiders				23
G-S2	Danilo	01/08/02	Gandawan	
Plutella xylostella				52
Spodoptera litura				2
Spiders				3
Myzus persicae				20
Beetle				1
D-US2	Janito	01/24/02	Lake Duminagat	
Plutella xylostella				46
Myzus persicae				3
Trichoplusia ni (larvae)				3
Grasshoppers				2
Hairy caterpillar				2
Spiders				10
D-S2	Rudy	01/24/02	Lake Duminagat	
Plutella xylostella				18
Myzus persicae				9
Spiders				9
Diptera (fly, mosquito)				2
Snail				3
Hairy caterpillar				1
D-D2	Carlos	01/24/02	Lake Duminagat	
Plutella xylostella				34
Trichoplusia ni (larvae)				5
Spiders				33
Day 3				
M-US3	Junnie	01/23/02	Mansawan	
Plutella xylostella				36
Spiders				4
Myzus persicae				8
Trichoplusia ni (larvae)				1
M-S3	Enerio	01/23/02	Mansawan	
Plutella xylostella				578
Myzus persicae				42
G-US3	Roger	01/22/02	Gandawan	
Plutella xylostella				217
Spodoptera litura				2
Trichoplusia ni (larvae)				22
Spiders				72
Beetle				2
Myzus persicae				14
Leafhoppers				1
G-S3	Danilo	01/22/02	Gandawan	
Plutella xylostella				353
Trichoplusia ni (larvae)				6
Spiders				15
Myzus persicae				3
Hairy caterpillars				3
D-US3	Janito	01/29/02	Lake Duminagat	
Plutella xylostella				22
Myzus persicae				1
Trichoplusia ni (larvae)				2

Trichoplusia ni (pupae)				1
Spiders				3
D-S3	Rudy	01/29/02	Lake Duminagat	
Plutella xylostella				22
Myzus persicae				1
Trichoplusia ni (larvae)				10
Spiders				3
D-D3	Carlos	01/29/02	Lake Duminagat	
Plutella xylostella				2
Myzus persicae				1
Spiders				45
Snail				1
Day 4				
M-US4	Junnie	01/31/02	Mansawan	
Plutella xylostella				161
Spiders				5
Trichoplusia ni (larvae)				1
Crocidolomia binotalis				1
M-S4	Enerio	01/31/02	Mansawan	
Plutella xylostella				1147
Crocidolomia binotalis				1
G-US4	Roger	01/30/02	Gandawan	
Plutella xylostella				125
Spiders				15
Myzus persicae				1
Fly				1
G-S4	Danilo	01/30/02	Gandawan	
Plutella xylostella				230
Trichoplusia ni (larvae)				1
Spiders				14
Myzus persicae				3
Beetle				1
D-US4	Janito	02/07/02	Lake Duminagat	
Plutella xylostella				248
Myzus persicae				2
Trichoplusia ni (larvae)				16
Spiders				5
D-S4	Rudy	02/07/02	Lake Duminagat	
Plutella xylostella				122
Myzus persicae				1
Spodoptera litura				14
Trichoplusia ni (larvae)				9
Spiders				2
D-D4	Carlos	02/07/02	Lake Duminagat	
Plutella xylostella				16
Trichoplusia ni (larvae)				3
Spiders				55
Day 5				
M-US5	Junnie	02/09/02	Mansawan	
Plutella xylostella				72

M-S5	Enerio	02/09/02	Mansawan	
Plutella xylostella				83
Trichoplusia ni (larvae)				2
Spiders				2
G-US5	Roger	02/08/02	Gandawan	
Plutella xylostella				41
Trichoplusia ni (larvae)				16
Trichoplusia ni (pupae)				2
Spiders				21
G-S5	Danilo	02/08/02	Gandawan	
Plutella xylostella				52
Trichoplusia ni (larvae)				1
Spiders				7
D-US5	Janito	02/13/02	Lake Duminagat	
Plutella xylostella				309
Trichoplusia ni (larvae)				29
Hairy caterpillar				2
Spiders				6
Aulacophora indica				1
D-S5	Rudy	02/13/02	Lake Duminagat	
Plutella xylostella				71
Myzus persicae				1
Spodoptera litura				2
Crocidolomia binotalis				1
D-D5	Carlos	02/13/02	Lake Duminagat	
Plutella xylostella				12
Trichoplusia ni (larvae)				1
Spiders				30
Snail				1
Hairy caterpillar				2
Beetle				1

Day 6

M-US6	Junnie	02/15/02	Mansawan	
Plutella xylostella				39
Spiders				6
Trichoplusia ni (larvae)				1
Spodoptera litura				3
M-S6	Enerio	02/15/02	Mansawan	
Plutella xylostella				27
Crocidolomia binotalis				1
Trichoplusia ni (larvae)				1
G-US6	Roger	02/14/02	Gandawan	
Plutella xylostella				9
Spodoptera litura				1
Trichoplusia ni (larvae)				18
Spiders				14
Unidentified worm				2
G-S6	Danilo	02/14/02	Gandawan	
Plutella xylostella				21
Trichoplusia ni (larvae)				9
Spiders				9

D-US6	Janito	02/21/02	Lake Duminagat	
Plutella xylostella				52
Crocidolomia binotalis				1
Spodoptera litura				1
Trichoplusia ni (larvae)				16
Spiders				4
Snail				1
D-S6	Rudy	02/21/02	Lake Duminagat	
Plutella xylostella				93
Myzus persicae				1
Crocidolomia binotalis				1
Trichoplusia ni (larvae)				2
D-D6	Carlos	02/21/02	Lake Duminagat	
Plutella xylostella				25
Trichoplusia ni (larvae)				2
Spiders				8

Day 7

M-US7	Junnie	02/23/02	Mansawan	
Plutella xylostella				72
Spiders				7
Crocidolomia binotalis				1
Spodoptera litura				7
M-S7	Enerio	02/23/02	Mansawan	
Plutella xylostella				56
Crocidolomia binotalis				6
Spodoptera litura				9
G-US7	Roger	02/22/02	Gandawan	
Plutella xylostella				63
Spodoptera litura				1
Trichoplusia ni (larvae)				21
Trichoplusia ni (pupae)				2
Spiders				13
Beetle				1
Hairy caterpillar				1
G-S7	Danilo	02/22/02	Gandawan	
Plutella xylostella				73
Trichoplusia ni (pupae)				1
Spiders				9
D-US7	Janito	02/28/02	Lake Duminagat	
Plutella xylostella				27
Crocidolomia binotalis				1
Spodoptera litura				1
Trichoplusia ni (larvae)				28
Trichoplusia ni (pupae)				1
Aulacophora indica				2
D-S7	Rudy	02/28/02	Lake Duminagat	
Plutella xylostella				51
Crocidolomia binotalis				3
Trichoplusia ni (larvae)				6
Spiders				2

D-D7	Carlos	02/28/02	Lake Duminagat	
Plutella xylostella				23
Myzus persicae				3
Trichoplusia ni (larvae)				10
Spiders				23
Day 8				
M-US8	Junnie	03/01/02	Mansawan	
Plutella xylostella				58
Spiders				5
Fly				10
Myzus persicae				2
Trichoplusia ni (larvae)				2
Snail				1
M-S8	Enerio	03/01/02	Mansawan	
Plutella xylostella				158
Crocidolomia binotalis				3
Trichoplusia ni (larvae)				6
Spiders				1
G-S8	Danilo	03/02/02	Gandawan	
Plutella xylostella				26
Trichoplusia ni (larvae)				4
Trichoplusia ni (pupae)				2
Crocidolomia binotalis				4
Spiders				11
Myzus persicae				1
D-US8	Janito	03/07/02	Lake Duminagat	
Plutella xylostella				59
Crocidolomia binotalis				1
Spodoptera litura				2
Trichoplusia ni (larvae)				18
Trichoplusia ni (pupae)				3
Grasshoppers				
Hairy caterpillar				2
Spiders				3
Aulacophora indica				1
Snail				3
D-S8	Rudy	03/07/02	Lake Duminagat	
Plutella xylostella				36
Trichoplusia ni (larvae)				7
Spiders				2
D-D8	Carlos	03/07/02	Lake Duminagat	
Plutella xylostella				63
Trichoplusia ni (larvae)				15
Spiders				40
Day 9				
M-US9	Junnie	03/08/02	Mansawan	
Plutella xylostella				59
Spiders				1
Myzus persicae				1
Crocidolomia binotalis				11
Til-As				1

M-S9	Enerio	03/08/02	Mansawan	
Plutella xylostella				127
Myzus persicae				1
Crocidolomia binotalis				6
Spodoptera litura				1
Trichoplusia ni (larvae)				2
Spiders				2
G-S9	Danilo	03/06/02	Gandawan	
Plutella xylostella				6
Trichoplusia ni (larvae)				7
Crocidolomia binotalis				3
Spiders				7
Myzus persicae				10
Beetle				1
Geometridae				3
Parasitic cocoons				one mass
Termite (Adult)				1
D-US9	Janito	03/14/02	Lake Duminagat	
Plutella xylostella				5
Spodoptera litura				2
Trichoplusia ni (larvae)				4
Trichoplusia ni (pupae)				1
Spiders				9
Wasp				1
Cocoon “semilooper”				one mass
D-S9	Rudy	03/14/02	Lake Duminagat	
Plutella xylostella				13
Spodoptera litura				1
Trichoplusia ni (larvae)				2
Spiders				6
Ants				1
Beetle				1
D-D9	Carlos	03/14/02	Lake Duminagat	
Plutella xylostella				37
Spiders				32
Day 10				
M-US10	Junnie	03/15/02	Mansawan	
Plutella xylostella				38
Spiders				3
Trichoplusia ni (larvae)				1
Crocidolomia binotalis				8
Til-As				1
M-S10	Enerio	3/15/02	Mansawan	
Plutella xylostella				76
Crocidolomia binotalis				51
Trichoplusia ni (larvae)				4
Spiders				1
Beetle				2
Grasshoppers				1
G-S10	Danilo	03/14/02	Gandawan	
Plutella xylostella				8
Trichoplusia ni (larvae)				2
Spiders				12
Ant (black)				1

D-US10	Janito	03/19/02	Lake Duminagat	
Plutella xylostella				3
Myzus persicae				5
Crocidolomia binotalis				1
Spodoptera litura				4
Trichoplusia ni (larvae)				2
Hairy caterpillar				1
Spiders				4
Aulacophora indica				3
Millipede				1
D-S10	Rudy	03/19/02	Lake Duminagat	
Plutella xylostella				10
Spodoptera litura				8
Trichoplusia ni (larvae)				2
Spiders				2
Beetle				2
Cocoon				one mass
Leafhoppers				1
D-D10	Carlos	03/19/02	Lake Duminagat	
Plutella xylostella				93
Spodoptera litura				1
Trichoplusia ni (larvae)				6
Trichoplusia ni (pupae)				1
Spiders				19
Snail				8
Day 11				
M-US11	Junnie	03/20/02	Mansawan	
Plutella xylostella				25
Spiders				13
G-S11	Danilo	03/14/02	Gandawan	
Plutella xylostella				15
Trichoplusia ni (larvae)				3
Spiders				8
Leafhoppers				1

TABLE 2. Arthropod sweep samples from Mt. Malindang.

Day 1				
M-S1	Enerio	01/12/02	Mansawan	sweep net
DBM				4
Formicidae				1
Tingidae				1
M-US1	Junnie	01/12/02	Mansawan	sweep net
Formicidae				1
Curculionidae				1
Cicadellidae				2
Cicadellidae 2				1
Muscoid				1
Acalyptrate				2
Spiders				3
G-S1	Danilo	01/08/02	Gandawan	sweep net
Ottitidae				1
Day 2				
M-S2	Enerio	1/16/02	Mansawan	sweep net
Chrysomelidae				1
Cicadellidae				1
Cicadellidae 2				3
Cicadellidae 3				1
Chloropidae				8
Phoridae				1
DBM				2
Braconidae				1
Spiders				5
Miridae				1
G-US2	Roger	01/15/02	Gandawan	sweep net
DBM				1
Tetrigidae				2
Spiders				10
G-S2	Danilo	01/15/02	Gandawan	sweep net
Spiders				1
DBM				2
Day 3				
M-S3	Enerio	01/26/02	Manswan	sweep net
Miridae				1
Chloropidae				5
Phoridae				1
Cicadellidae				3
Cerambycidae				1
DBM				2
Spiders				6
D-D3	Carlos	1/24/02	Lake Duminagat	sweep net
Sciaridae				2
Curculionidae				1
Muscidae				1
Tetrigidae				1

Anthocoridae				1
DBM				2
Chloropidae				6
Spiders				19
Cicadellidae				1
D-S3	Rudy	1/24/02	Lake Duminagat	sweep net
DBM				7
Cicadellidae				1
Tetrigidae				2
Formicidae				2
Lauxanidae				1
Chloropidae				3
Cotesia sp.				1
Day 4				
M-S4	Enerio	1/31/02	Mansawan	sweep net
DBM				44
Drosophilidae				1
Tipulidae				2
Rhagionidae				1
Acalyptrate				1
M-US4	Junnie	01/31/02	Mansawan	sweep net
DBM				108
Spiders				1
Anthomyiidae				1
Drosophilidae				1
Delphacidae				1
Acalyptrate				1
Cicadellidae				
G-US4	Roger	01/30/02	Gandawan	sweep net
Spiders				6
Acalyptrate				1
DBM				1
G-S4	Danilo	01/30/02	Gandawan	sweep net
Semilooper				2
DBM				15
Sciomyzidae				1
Anthomyiidae				2
Spiders				3
Chloropidae				1
D-US4	Janito	01/29/02	Lake Duminagat	sweep net
Cicadellidae				1
DBM				6
Dolicophodidae				1
Acalyptrate				8
Spiders				4
Formicidae				1
D-D4	Carlos	01/29/02	Lake Duminagat	sweep net
Elateridae				2
Spiders				15
Braconidae				1
Acalyptrate				4
DBM				1

D-S4	Rudy	01/29/02	Lake Duminagat	sweep net
Cotesia sp.				1
Syrphidae				1
Tipulidae				1
Cecidomyiidae				3
Braconidae				1
Cicadellidae				1
Tetrigidae				1
Spiders				3
Rhagionidae				1
DBM				1

Day 5

M-S5	Enerio	02/09/02	Mansawan	sweep net
Chloropidae				2
Miridae				1
DBM				1
Spider				1
Formicidae				2
M-US5	Junnie	2/9/02	Mansawan	sweep net
DBM				14
Cicadellidae				1
Drosophilidae				3
Chloropidae				6
Formicidae				1
Formicidae 2				3
Formicidae 3				1
Spiders				1
G-US5	Roger	02/08/02	Gandawan	sweep net
Spiders				15
DBM				11
Cicadellidae				1
Cotesia sp.				2
G-S5	Danilo	02/08/02	Gandawan	sweep net
DBM				20
Spiders				6
Halictus sp.				1
Tipulidae				2
Cicadellidae				1
Phoridae				1
Cecidomyiidae				1
Semilooper				2
D-S5	Rudy	02/07/02	Lake Duminagat	sweep net
DBM				6
Spiders				7
Miridae				1
Delphacidae				1
Cicadellidae				1
Chloropidae				1
D-US5	Janito	02/07/02	Lake Duminagat	sweep net
DBM adult				16
Semilooper				1
Spiders				8
Curculionidae				1
Tetrigidae				1
Chloropidae				1
Chrysomelidae				1
Thrips				1

D-D5	Carlos	02/07/02	Lake Duminagat	sweep net
Spiders				14
Chloropidae				2
Cecidomyiidae				1
DBM				5

Day 6

M-S6	Enerio	2/12/02	Mansawan	sweep net
Formicidae				1
Cicadellidae				1
DBM				17
Chloropidae				12
Tephretidae				1
Drosophilidae				1
M-US6	Junnie	02/15/02	Mansawan	sweep net
Vespidae				1
Braconidae				2
Tipulidae				1
Chloropidae				32
Spider				1
DBM				6
G-US6	Roger	2/13/02	Gandawan	sweep net
Tachinidae				1
Spider				1
DBM				1
G-S6	Danilo	2/13/02	Gandawan	sweep net
DBM				4
Sciaridae				1
Ottitidae				1
Spiders				1
Sciaridae				1
D-S6	Rudy	2/13/02	Lake Duminagat	sweep net
DBM				15
Formicidae				1
Formicidae 2				1
Dolichopodidae				1
Chloropidae				10
Chloropidae 2				1
Semilooper				1
Spiders				4
D-D6	Carlos	2/13/02	Lake Duminagat	sweep net
Tipulidae				1
DBM				2
Chrysomelidae				1
Delphacidae				1
Staphylinidae				1
Spider				9
Diapriidae				1

D-US6	Janito	2/13/02	Lake Duminagat	sweep net
DBM				9
Tipulidae				1
Formicidae				1
Chloropidae				3
Spiders				2
Chloropidae 2				1
Semilooper				1
Day 7				
D-US7	Janito	2/21/02	Lake Duminagat	sweep net
Semilooper				4
DBM				23
Dolichopodidae				1
Miridae				1
Curculionidae				1
Spiders				2
Chloropidae				1
D-D7	Carlos	02/21/02	Lake Duminagat	sweep net
DBM				1
Spiders				10
Ichneumonidae				1
Dolichopodidae				1
Musca domestica				1

Table 3. Arthropod pitfall trap samples from Mt. Malindang.

Day 1				
M-US1	Junnie	01/09/02	Mansawan	pitfall trap
Cutworm				3
M-S1	Enerio	01/12/02	Mansawan	pitfall trap
Formicidae				33
Formicidae 2				12
DBM				4
Amphipoda				1
Spiders				3
Cicadellidae				1
Entomobryidae				16
Scarabaeidae				1
Staphylinidae				1
Delphacidae				2
Cecidomyiidae				1
Solenopsis sp.				3
Mycetophilidae				1
G-S1	Danilo	01/15/02	Gandawan	pitfall trap
Staphylinidae				1
Cerambycidae				1
Phalangidae				1
Sowbugs				11
Miridae				1
Formicidae				3
Calyptrate				5
Day 2				
M-S2	Enerio	1/31/02	Mansawan	pitfall trap
Gryllacrididae				2
Blatellidae				1
Staphylinidae				1
Formicidae				1
Phoridae				1
Tenebrionidae				1
Spiders				5
Cecidomyidae				1
Chrysomelidae				1
M-US2	Junnie	01/31/02	Mansawan	pitfall trap
DBM				1
Formicidae				2
Drosophilidae				1
Delphacidae				1
Cicadellidae				1
Staphylinidae				1
Miridae				2
Acalyptrate				16
Chloropidae				12
Spiders				2
G-S2	Danilo	01/30/02	Gandawan	pitfall trap
Gryllacrididae				2
DBM				3
Gryllidae				1
Formicidae				7
Spiders				5

Cecidomyidae				1
Lygaeidae				2
Curculionidae				1
Staphylinidae				2
Collembola				1
Braconidae				3
Isopoda				1
G-US2	Roger	1/30/02	Gandawan	pitfall trap
Sphecidae				1
Ichneumonidae				1
Braconidae				1
DBM				1
Staphylinidae				1
Coccinellidae				1
Chrysomelidae				1
Cecidomyiidae				2
Mycetophilidae				1
Tipulidae				1
Phoridae				1
Gryllacrididae				1
Spiders				2
D-D2	Carlos	01/29/02	Lake Duminagat	pitfall trap
Spiders				1
Amphipoda				2
Cecidomyiidae				1
Fomicidae				1
Lycaedae				1
Chrysomelidae				1
Phalangidae				1
Entomobryidae				1
D-S2	Rudy	01/29/02	Lake Duminagat	pitfall trap
Spiders				4
Amphipoda				3
Formicidae				11
Elateridae				1
Curculionidae				2
Tenelerionidae				1
Phalangidae				1

Day 3

M-US3	Junnie	2/9/02	Mansawan	pitfall trap
Gryllidae				1
Phoridae				1
Formicidae				2
Aphididae				1
Formicidae 2				1
Formicidae 3				2
Carabidae				1
Spiders				2
M-S3	Enerio	2/09/02	Mansawan	pitfall trap
Chrysomelidae				1
Gryllidae				1
Blattidae				1
Carabidae				1
DBM				1

G-S3	Danilo	02/08/02	Gandawan	pitfall trap
Chrysomelidae				1
Formicidae				3
Lygaeidae				1
Coccinellidae				1
DBM				2
Unidentified sp.				7
D-D3	Carlos	1/24/02	Lake Duminagat	pitfall trap
Scelionidae				1
Curculionidae				1
Carabidae				1
Spiders				2
Amphipoda				2
Phalangida				2
D-US3	Janito	1/24/02	LakeDuminagat	pitfall trap
Cleridae				1
Staphylinidae				2
Formicidae				45
Formicidae 2				8
DBM				1
Chrysomelidae				1
Formicidae 3				1
Coccinellidae				1

Day 4

M-S4	Enerio	2/15/02	Mansawan	pitfall trap
Formicidae				1
Earwig				1
Cicadellidae				1
Delphacidae				1
Phalangida				1
M-US4	Junnie	2/15/02	Mansawan	pitfall trap
Gryllacrididae				1
Sepsidae				1
Staphylinidae				2
Carabidae				1
Formicidae				37
Formicidae 2				1
Formicidae 3				4
Formicidae 4				1
Phoridae				2
Curculionidae				1
Coccinellidae				1
Anobiidae				1
DBM				2
G-S4	Danilo	2/12/02	Gandawan	pitfall trap
Noctuidae				3
Staphylinidae				2
Formicidae				1
Formicidae 2				1
Curculionidae				1
Elateridae				1
Tetrigidae				1
Amphipoda				54
Spiders				2
Isopoda				2

G-US4	Roger	2/13/02	Gandawan	pitfall trap
Staphylinidae				2
Coccinellidae				1
Chrysomelidae				1
Formicidae				1
Spiders				3

D-D4	Carlos	02/13/02	Lake Duminagat	pitfall trap
Phalangida				2
Amphipoda				2
Aphididae				1
Formicidae				1
Spiders				1

D-US4	Janito	2/13/02	Lake Duminagat	pitfall trap
Phalangida				1
Gryllacrididae				1
Tetrigidae				1
Gryllidae				4
Earwig				1
Formicidae				3
Formicidae 2				2
Cecidomyiidae				1
Aphididae				2

D-S4	Rudy	2/13/02	Lake Duminagat	pitfall trap
Drosophila sp.				1
Dolichopodidae				1
Cerambycidae				1
Formicidae				2
Tetrigidae				2
Gryllacrididae				1
Sciaridae				1
Phalangida				1
Amphipoda				73
Isopoda				2
DBM				1

Day 5

D-US5	Janito	2/21/02	Lake Duminagat	pitfall
Staphylinidae				1
Staphylinidae 2				1
Formicidae				21
Formicidae 2				3
Gryllidae				3
Earwig				1
Millipede				3
Amphipoda				5
DBM				2

D-S5	Rudy	02/21/02	Lake Duminagat	pitfall trap
DBM				3
Spiders				3
Termitidae				1
Formicidae				4
Staphylinidae				1
Aphididae				2
Semilooper				1
Amphipoda				84
Millipede				2

D-D5	Carlos	02/21/02	Lake Duminagat	pitfall trap
Gryllacrididae				1
Braconidae				1
Ichneumonidae				1
Earwigs				5
Phalangida				1
Carabidae				1
Staphylinidae				2
DBM				1
Spiders				3
Phoridae				1
Drosophilidae				1
Phoridae				1
Amphipoda				34

Table 4. Arthropod samples collected from sticky traps from Mt. Malindang.

Day 1				
G-S1	Danilo	01/08/02	Gandawan	sticky trap
Miridae				2
Tipulidae				2
Cecidomyiidae				15
Cerambycidae				1
Psen sp.				1
Bethylidae				1
Tiphiidae				1
G-US1	Roger	01/08/02	Gandawan	sticky trap
Spiders				5
Cicadellidae				2
Languriidae				1
Chrysomelidae				8
Tipulidae				1
Sciaridae				1
Drosophilidae				1
Neriidae				1
Acalyptrate				2
Day 2				
M-S2	Enerio	01/12/02	Mansawan	sticky trap
DBM adult				4
Formicidae				1
Stratiomyidae				1
Drosophilidae				1
Staphylinidae				1
Braconidae				1
Acalyptrate				1
Delphacidae				1
Mycetophilidae				1
G-S2	Danilo	01/15/02	Gandawan	sticky trap
Cotesia sp.				2
Curculionidae				1
Cecidomyiidae				1
Day 3				
M-US3	Junnie	1/23/02	Mansawan	sticky trap
Aphididae				7
Sciaridae				5
Delphacidae				1
Dolichopodidae				1
Phoridae				2
Tipulidae				4
Chloropidae				1
M-S3	Enerio	1/23/02	Mansawan	sticky trap
DBM				21
Sciaridae				1
Tipulidae				2
Delphacidae				1
D-D3	Carlos	1/24/02	Lake Duminagat	sticky trap
Drosophilidae				1
Tipulidae				2

Phoridae				1	
Chrysomelidae				1	
Delphacidae				1	
D-S3	Rudy	1/24/02	Lake Duminagat	sticky trap	
Delphacidae				2	
Formicidae				1	
Chrysomelidae				1	
Tipulidae				1	
Day 4					
M-US4	Junnie	01/31/02	Mansawan	sticky trap	
Tipulidae				1	
Chalcididae				1	
M-S4	Enerio	01/31/02	Mansawan	sticky trap	
Spiders				2	
DBM				1	
Entomobryidae				1	
Leeches				3	
Unidentified larva				1	
G-S4	Danilo	01/30/02	Gandawan	sticky trap	
Braconidae				1	
Lygaeidae				1	
G-US4	Roger	01/30/02	Gandawan	sticky trap	
Curculionidae				1	
Chrysomelidae				1	
Cotesia sp.				1	
Acalyptrate				1	
Cecidomyiidae				2	
D-S4	Rudy	01/29/02	Lake Duminagat	sticky trap	
Cecidomyiidae				3	
Ottitidae				1	
D-US4	Janito	01/29/02	Lake Duminagat	sticky trap	
Cicadellidae					
Cecidomyiidae				1	
Formicidae				1	
Aphididae				1	
D-D4	Carlos	01/29/02	Lake Duminagat	sticky trap	
Cicadellidae				1	
Flatidae				1	
Muscoid				1	
Tephretidae				1	
Drosophilidae				1	
Acalyptrate				1	
Bracon sp.					
Day 5					
M-US5	Junnie	2/9/02	Mansawan	sticky trap	
Aphididae				8	
DBM				2	
Tipulidae				1	
Phoridae				4	
Sciaridae				4	
Formicidae				2	
Staphylinidae				1	
Chloropidae				8	

M-S5	Enerio	2/9/02	Mansawan	sticky trap
Tipulidae				2
Sciaridae				1
Formicidae				1
Chloropidae				22
Dolichopodidae				1
Phoridae				3
Delphacidae				1
G-US5	Roger	02/08/02	Gandawan	sticky trap
Spiders				2
G-S5	Danilo	02/0802	Gandawan	sticky trap
DBM				2
D-US5	Janito	02/07/0	Lake Duminagat	sticky trap
Braconidae				2
Empididae				1
Cecidomyiidae				1
Ricaniidae				1
Ciixidae				1
Tipulidae				1
Mycetophilidae				1
Nogodinidae				1
Unidentified sp.				1
Day 6				
M-S6	Enerio	2/15/02	Mansawan	sticky trap
Chloropidae				4
Phoridae				1
Scelionidae				1
M-US6	Junnie	2/15/02	Mansawan	sticky trap
Aphididae				2
Chloropidae				4
Formicidae				3
Sciaridae				4
Phoridae				1
G-S6	Danilo	2/13/02	Gandawan	sticky trap
Chrysomelidae				1
Bethylidae				1
D-US6	Janito	2/13/02	LakeDuminagat	sticky trap
Tipulidae				1
Sciaridae				2
Aphididae				3
Delphacidae				2
Phoridae				1
D-D6	Carlos	2/13/02	LakeDuminagat	stickytrap
Formicidae				7
Bibionidae				1
Chrysomelidae				1
DBM				1
Phoridae				1

Project Leader: **Emma M. Sabado**
Co-project Leader: **Stephen G. Reyes**
Research Assistant: **Esteban T. Padogdog, Jr.**
Local Partners: **Enerio Pacante, Junnie Gumola, Roger Empil, Danilo Empil, Rudy Penalte, Janito Tamon, Carlos Gomistil**

Editing/Layout: **Sylvia Katherine S. Lopez**
Production Assistant: **Carina S. Fule**

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

National Support Secretariat (NSS)
SEAMEO SEARCA, College, Laguna
4031 Philippines

Site Coordinating Office (SCO)
Don Anselmo Bernad Avenue
cor. Jose Abad Santos St.
Ozamiz City
7200 Philippines

ISBN 971-560-106-5