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Butterfly Diversity, Abundance and Distribution in Six Different Land use Patterns in Gumay and Setema Districts, Jimma zone, Southwestern Ethiopia

By

Tsegab Temesgen

A Thesis Submitted to the Department of Biology, School of Graduate Studies, Jimma University, in Partial Fulfillment of the Requirement for the Degree of Master of Science in Biology (Ecological and Systematic zoology)

October, 2015

Jimma, Ethiopia

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Advisers: Delenesaw Yawhalew (PhD)

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October, 2015

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Declaration

I, hereby, declare that the thesis comprises my own work and has not been submitted to the award of academic degree at this or any other university, Exceptions are the sections where previous knowledge is stated in which references have been duly provided. This thesis has been submitted in partial fulfillment of the requirements for MSc. Degree at Jimma University and is deposited at the university library to be made available to borrowers under rules of the library.

Name: Tsegab Temesgen

Signature………………………….

Date…………………………………

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Acronyms and abbreviation

ANISOM	Analysis of Similarity
ANOVA	Analysis of variance
CHIESA	Climate Change Impacts on Ecosystem Services and Food Security in Eastern Africa
CL	Crop Land
GPS	Global Positioning System
NF	Natural Forests
PAS	Pasture Land
PAST	Paleontological Statistics Software
PLA	Plantation
SMCF	Semi Managed Coffee Forest
SPSS	Statistical Package for Social Sciences
WL	Woodland

Abstract

The diversity, abundance and distribution of butterflies in six habitat types/land use patterns (Semi Managed Coffee forest /limited human involvement, Natural Forest, Plantation, Wood Land, Pastureland and Cropland in landscapes of Gumay and Setema districts of Jima zone, southwestern Ethiopia were studied for five months (January 2015 to June 2015). Sampling of butterflies was conducted using line transects and, walk-and-count methods. Hand nets were used to sample butterflies in both methods. Collections were made for ten days along 20 km transect in each month from 29 hectors of land, each hector was considered as a study plot. The similarity of species among habitats types (Bray-Curtis similarity) was analyzed with cluster analysis using Paleontological Statistics (PAST) software version 2.17.A total of 6,993 butterflies belonged to 70 different species in five families *were recorded in the study period. Of these* 3,200(45.76%) butterflies belonged to Family Nymphalidae, 2,603(37.22%) family Pieridae, 913(13.05%) family Lycanidae, 272(3.89%) family Papilionidae and only 5(0.07%) belonged to family Hesperidae. *Mean butterfly density per plot per month was 444(29%) from natural forest, 357(24.98%) from semi managed coffee forest, 300(18.99%) from plantation forest, 242 (16.12%) from woodland, 100 (6.66%) from pasture and 58(3.86%) individuals of butterfly from cropland. Species richness index and diversity index was highest in natural forest (8.3 and 3.7 respectively) and lowest in the cropland (4.1 and 2.8 respectively) and Evenness index was highest in natural forest and lowest in woodland (0.89 and 0.66 respectively). Butterfly species similarity was highest in the semi managed coffee forest and plantation forest (S=93%), and least in the pasture and natural forest (S=20%). There was significant association between month and butterfly diversity and between month and butterfly abundance ($P < 0.05$). The findings of the study indicate that butterfly diversity and abundance were higher in natural forest and semi managed Coffee forest but lower in Wood land, Pastureland and Croplands.*

1. Introduction

Studying biological diversity is now increasingly being recognized as a vital parameter to assess the global and local environmental changes and sustainability of developmental activities of various species (Rajagopal *et al*., 2011). Collection of baseline data on animal biodiversity is relevant for environmental risk assessment and risk management but it is still far from being achieved (CBD, 2013). Tropical forests are a key biome to the biodiversity of the world (Gardner *et al*., 2009) but are subject to massive past and current degradation (Bradshaw *et al*., 2008).The dominant immediate driver of biodiversity losses and ecosystem service changes is human-induced habitat modifications (MEA, 2005).

Butterflies have formed one of the most visible, but not always noticed components of the biodiversity (Willis and Woodhall, 2010). Butterflies depend on the forest for survival due to the provision of favorable habitats and resources such as cover, moderate temperature, humidity and food sources (Humpeden and Nathan, 2010). Insect diversity is highest in habitats with the most plant diversity and is lowest in shrub, grass and open areas (DeVries, 1992). This shows that a forest habitat with more forest canopy layers and high vegetation diversity supports more insect species than a forest habitat with less forest canopy layers and less vegetation diversity. Dover *et al*. (1997) discussed the importance of shelter in the open countryside for butterflies.

Butterfly diversity and abundance are influenced by climatic conditions such as sunshine and temperature (Kremen, 1992). They are strongly influenced by the amount of energy available during favorable season (Grimaldi and Engel, 2005).Many authors documented the influence of landscape patterns on butterfly community (Schneider *et al*., 2003; Summerville and Crist, 2003, 2004). Features of landscapes are the most important predictors that influence the population and community ecology of species (Hunter, 2002 and Tews *et al*., 2004). Hill *et al*. (2001) showed that the habitat availability was an important determinant of expansion rates. Saarinen (2002) concluded that the occurrence of many butterfly species is determined by the floral composition of the field border, in particular the abundance of larval host plants and adult nectar plants.

Butterflies play a pivotal role in determining the stability of ecosystem since their numbers can fluctuate drastically with even slight changes in temperature, weather conditions, degradation or pollution. It is well known that some human activity has negative impacts on butterflies (White and Kerr, 2007). They also serve as indispensable links in food web in many ecosystems and niches they inhabit (Mader, 2003). In addition, butterflies have been identified as bioindicators, capable of representing the overall health of the environment (Prabakaran *et al*., 2014). They provide important ecological services for crops and native wild plant species in many ecosystems of the world, their conservation is essential to sustain the productivity of natural and agricultural landscapes (Davis *et al*., 2008). However, the protection, conservation, and utilization of Lepidoptera pollinator require extensive understanding of their foraging behaviors and of their temporal and spatial distribution in agricultural landscapes (Fitzherbert *et al*., 2006; Kuefler, 2008).

So, to enhance ecosystem services of butterflies monitoring of their diversity can be an important tool to assess their status and revise their conservation strategies in rural landscapes. The identification of indicator species may help in guiding monitoring programs of these insects as well as helping in setting appropriate conservation strategies related to proper management of rural landscape habitats. Thus, this study was designed to provide base line data on butterflies diversity, abundance and distribution in different land use patterns in Gumay and Setema districts southwestern Ethiopia.

1.1. Statement of the problem

There is a lack of empirical data on butterflies from farmland habitats in sub-Sahara Africa (Davis *et al*., 2008). To the best of our knowledge there is no published data exists describing the diversity of butterflies found in agricultural landscapes. However, such information is important for butterfly biodiversity and ecosystem services conservation on farmlands. Butterflies provide important ecological services for crops and native wild plant species in many ecosystems of the world and their conservation is essential to sustain the productivity of natural and agricultural landscapes (Davis *et al*., 2008).

There have not been many studies on the diversity of butterfly communities in tropical forests within different land use patterns including semi managed coffee forest (it was natural forest before and some of the forest plants was removed and replaced by coffee plant).

Semi managed coffee forest may play an important role in conserving a portion of tropical biodiversity of which insects are a major part but little data is available.

Study shows that even in small study area butterfly communities varied significantly among different habitats (Ramesh *et al*., 2010). DeVries (1992) showed that insect diversity is highest in habitats with the most plant diversity and are lowest in shrub, grass and open areas.

Therefore, this study was conducted to assess the status of butterfly and compare diversity, abundance and distribution in natural forest, semi managed coffee forest, plantations, pastureland, woodland and cropland in Gumay and Setema districts of Jimma zone southwestern Ethiopia.

1.2. Objectives

1.2.1. General objective

The general objective of this study was to assess butterfly diversity, abundance and distribution in six different land use patterns in Gumay and Setema districts of Jima zone, southwestern Ethiopia

1.2.2. Specific objectives

- To determine the species composition of butterfly in six different land use patterns in Gumay and Setema districts of Jima zone, southwestern Ethiopia.
- To determine butterfly abundance and diversity among six different land use patterns in the study area.
- To compare butterfly evenness and species richness among six different land use patterns in the study area.
- To determine butterfly species similarity in six different land use patterns in the study area.
- To determine butterfly population dynamics overtime in the study area.

1.3. Significance of the study

Roughly 90% of butterfly species live in the tropics. Despite this, we know very little about tropical butterfly ecology particularly when compared to temperate butterfly systems. The relative scarcity of data on tropical butterfly populations hinders our ability to effectively conserve them (Bonebrake, *et al*., 2010). Butterflies are likely to be important pollinators in Ethiopian agriculture, it appears very important to set conservation measures to protect them in farmlands. Monitoring of their diversity can be an important tool to assess their status and revise their conservation strategies in rural landscapes. The identification of indicator species may help in guiding monitoring programs of these vital organisms as well as helping in setting appropriate conservation strategies related to proper management of rural landscape habitats.

Thus, this study was intended to provide base line data on butterflies in the study area for future diversity study and provide information on the general awareness of these insects.

2. Literature review

2.1. Butterfly biology and ecology

Butterfly diversity, abundance and distribution are influenced by climatic conditions such as sunshine and temperature (Stefanescu *et al*., 2003, Grimaldi and Engel, 2005). This is due to the extreme ectothermic behavior of adult butterflies which depends on both warm air and direct sunshine (Gibson *et al*., 1992). This is supported by the species-energy hypothesis which states that diversity within terrestrial habitats is more or less directly controlled by the amount of solar energy available, and declines with latitude as input from the sun to the earth's surface and this affect species diversity (Wright, 1983).

The metabolism of butterfly depends strongly on climatic condition (Watt, 2003).Therefore warmer temperatures instead of low temperature directly benefit butterflies because, it enables individuals may be to spend more time acquiring resources (Boggs and Murphy, 1997). On the other hand, the release and accumulation of excessive temperature through global warming affect the diversity, abundance and distribution of butterflies (Microsoft Encarta, 2008).

The global warming changes the quantity and quality of habitats available to butterfly species; that are the range of temperature, rainfall and other climate related parameters in which the butterfly species exist (James *et al*., 2003).

Several environmental factors such as climate and rainfall affect resource availability and habitat diversity (Currie, 1991). This means that climate and rainfall does not only affect the butterflies directly but also affect resource availability and habitat diversity (Connell, 1978). For instance, the rainfall affects butterflies due to their positive effects on the vegetation growth which serves as resource for butterflies (Hill, 1999). So changes in the temperature and rainfall could affect the diversity and abundance of butterflies (Kremen, 1992).

Human disturbance is another factor that affects butterfly diversity and abundance. The effect of human disturbance on butterfly diversity and abundance is not based on the disturbance affecting the butterflies directly. Rather the disturbance on the forest ecosystem which results in large scale modification and destruction of the forest (Fahrig, 2003). This leads to huge losses of forest biodiversity which may affect butterfly species diversity and abundance (Griffis *et al*., 2001).

The loss of habitat through fragmentation removes some specific plants species that provide the trophic resources for caterpillars of butterflies as well as nectar which also supply the adults with food to survive (Brown, 1997). The loss of biodiversity as result of destruction of habitat also affects conditions that affect species (Webster, 1979). Therefore habitats of butterflies that are destroyed affect conditions that support the survival of them. Examples of them are climate (Currie, 1991), rainfall and light (Guison *et al*., 1995).

On the other hand, the habitats which are mostly vegetation where butterflies dwell have good composition of plant species (Gaston, 1992). Their threat both in the early stages by parasitoid and adult stage by predators, diseases and environmental condition are reduced with good habitat. For example parasitoids and predators are defended by butterflies based on chemicals released from body parts which are obtained from plants toxins and they use them instead of their own defense (Nishida and Ritsuo, 2002) and the chemicals obtained for their defense are plants based which in turn are based on the habitat with enough plants species. The vegetation can also play an important role for butterfly survival offering particular structural elements for sun-basking, mating and even suitable microclimates production (Dover *et al*., 1997). The act of grazing by farm animals has threatened many species of plants and this in turn affects the butterfly species richness. The continuous grazing results in year-to-year variation in temperature that kills certain butterfly species (Hoyle and James, 2005). Generally, the relation between butterfly diversity and distribution is in relation to the habitat suitability on variety of plant resources (Gaston, 1992).

Butterflies play crucial role in food chain as primary consumers, and they are affected by secondary consumers during energy flow through food chain (Mader, 2003).This affects the butterfly diversity and abundance in its habitat (Bailowitz and Sitter, 2005). The loss of butterflies occurs mostly when the eggs are eaten and the hatched eggs into larva are fed on by birds and other species (Thomas, 2005). The butterfly diversity is intensely affected especially during limited resources, and when there are many predators (Fahrig, 2003). The predation may affect the adults to breed because parts of the mates are reduced during the predation. The larva that continue the generations are fed on by consumers to create a gap in the growth cycle which affect the diversity (Mader, 2003).

2.2. Butterfly diversity

Insects constitute about 70% of all life forms on the earth (Scott, 1999). Currently there are more than 18,000 butterfly species exist on different parts of the world (Emmel and Larsen, 1996). Neotropical region Africa is the second world's richest place for butterflies. About 3,600 butterfly species have been identified in the Afro tropical region, which represents 20% of the butterflies across the world (Larsen, 2006). Butterfly diversity of Africa is high (Emmel and Larsen, 1996).

2.3. Butterfly taxonomy

Taxonomically all butterflies belongs to class Insecta Order Lepidoptera. Lepidoptera can be divided in to two groups, Rhopalocera and Heterochera and all butterflies are groups under Rhopalocera (Corbet and Pendlebury, 1992). The Rhopalocera can be divided in to two sub group; Papilonidea (true butterflies) and Hesperiodea (skippers). They are further divided in to five families namely Papilonidae, Pieridae, Lycaenidae, Nymphalidae and Hesperiidae (Larsen, 1996).

2.3.1. Papilionidae (swallowtail butterfly)

Swallowtail butterflies are large, colorful butterflies, and include over 550 species (Hauser *et al.*,2005).Though the majorities are tropical, members of the family inhabit every continent except Antarctica. The family includes the largest butterflies in the world, the bird wing butterflies of the genus Ornithoptera (Reed *et al.*, 2006).

The forked appearance of the swallowtails' hind wings, which can be seen when the butterfly is resting with its wings spread, gave rise to the common name swallowtail.

2.3.2. Pieridae "butter colored fly"

The butterfly in this family is moderate to fairly small in size. Pieridae tend to be easy to identify by their bright colors. They are a large family of butterflies with about 76 genera containing approximately 1,100 species, mostly from tropical Africa and tropical Asia (Braby, 2005). Most pieridae butterflies are white, yellow or orange in coloration, often with black spots. The pigments that give the distinct colorings to these butterflies are derived from waste products in the body and are a characteristic of this family (Braby *et al.*, 2006).

It is believed that the name "butterfly" originated from a member of this family the Brimstone *Gonepteryx rhamni* which was called the "butter-colored fly" by early British naturalists (Braby *et al.,* 2006).

The sexes usually differ, often in the pattern or number of the black markings. The larvae (caterpillars) of a few of these species, such as *Pieris brassicae* and *Pieris rapae*, commonly seen in gardens, feed on brassicas, and are notorious agricultural pests. Males of many species exhibit sociable mud puddling behavior when they may drink salts from moist soils (Braby, 2005).

2.3.3. Nymphalidae (brush-footed butterflies)

The family Nymphalidae is the most specious family of butterflies with about 6000 described species with a great variety of shape, bright colors and markings. They are commonly known as nymphalids, brush foots, or brush-footed butterflies. The family includes many large, strong fliers and many species are attracted and found in open and also sunny areas. However, there are a number of species which are restricted to the forests. The family contains many well known species, such as the monarch, the Painted Lady, the buckeye, the fritillaries, checker spots and the electric blue morphos. Indeed, nymphalids are in many places the most visible members of the local butterfly fauna. Due to their visibility and ease of study in the field and lab, many species of nymphalids have been used as model systems to understand the complexity of life on this planet.

2.3.4. Lycaenidae (gossamer-winged butterflies)

The Lycaenidae is a large family of small butterflies, many of which have tailed hind wings. This family contains three main groups of butterflies, the hairstreaks, coppers and blues, each identified by various external characteristics. Metallic colors are the most common.

Lycaenidae is the second largest family of butterflies (behind the brush footed butterflies), with over 5,000 species worldwide (Fiedler, 1996). Whose members are also called gossamer winged butterflies. They constitute about 30% of the known butterfly species.

The family is traditionally divided into the subfamilies of the blues (Polyommatinae), the coppers (Lycaeninae), the hairstreaks (Theclinae), and the harvesters (Mileetinae), (Hall and Harvey, 2002).

Adults are small, fewer than 5 cm usually and brightly colored, sometimes with a metallic surface shine. Larvae are often flattened rather than cylindrical, with glands that may produce secretions that attract and suppress ants. Their cuticles tend to be thickened. Some larva is capable of producing vibrations and low sounds that are transmitted through the substrates they inhabit. They use these sounds to communicate with ants (Pierce *et al*., 2002).

2.3.5. Hesperiidae (skipper butterfly)

A skipper or skipper butterfly is a butterfly of the family Hesperiidae. They are named after their quick, darting flight habits. More than 3500 species of skippers are recognized, and they occur worldwide, but with the greatest diversity in the Neotropical regions of Central and South America ((Burns *et al*., 2007).

The Hesperiidae are distinguished from all other butterflies by their short, wide bodies and relatively short wings; they look more like moths than butterflies. The clubbed or hooked antennae are set wide apart on the head. Most are grey or brown with lighter markings, although some are more colorful.

2.4. Butterfly distribution and its ecological importance

Butterflies are the most efficient pollinators of flowers in addition to moths and bees. They help in production of food crops, seeds and fruits; therefore, they are essential for the survival of man and animals (Maheshwari, 2003). Butterflies play a critical role in determining the stability of an ecosystem since their numbers can fluctuate severely with even slight changes in temperature, weather conditions, degradation or pollution and they are good indicators in terms of anthropogenic disturbance and habitat quality (Bergman *et al*., 2008; Bonebrake *et al*., 2010).

Butterflies are the most plentiful group of insects on the earth, which are accustomed among the public and science due to their striking colors and elegant flight. These are found in every part of the world wherever the flowering plants are found residing even very high altitude except some regions such as Ant- arctic, Arctic, mountains roofed with everlasting snow and glaciers (Khan *et* *al*., 2004). They have a widespread distribution, are comparatively easy to sample and recognize, and both as individuals and as species, they show significant numbers in different ecosystems. They are also strongly influenced by local weather and highly sensitive to environmental changes besides being charismatic insects that could fascinate the public attention. Butterflies are extremely sensitive to changes in vegetation composition and structure, and different types of vegetation show different butterfly species composition (Sawchik *et al*., 2005).

The Eastern African Coastal forests are rich in endemism and diversity of biological species and are globally recognized among areas of great biological importance and diversity (Tanzanian Forest conservation group, 2012)

3. Materials and Methods

3.1. Study area and period

This study was conducted in Jimma highlands of Oromia region southwestern Ethiopia along the study transect which connects Gumay and Setema districts (Figure 1). The study was conducted for five rounds (first round from 31 December 2014 to 9 January 2015, second round from 26 Jan. to 5 Feb. 2015, third round from 28 March to 6 April 2015 fourth round from 2 May to11 May 2015 and fifth round from 1 June to 10 June 2015).

The transect encompasses six different land use patterns which included: Semi-Managed Coffee Forest, Woodlands, Pasture, Cropland, Natural forests and Plantation Forests. The study area was about 70 km northwest of Jimma in the upper Diddessa river catchment area. The study transect was located between 36.27-36.47 E and 8.02-8.03 N and its elevation ranges from1500-2200 m above sea level. Jimma highland gets heavy rain for eight months (March-October) and characterized by uni-modal rainfall pattern. The mean annual maximum temperature ranges from 26-28 °C and mean annual minimum temperature ranges from 3.0 to 12°C.

3.2 Vegetation type of study area

There are a variety of plant species in different land use patterns in the study area (Bakele, A., 2007)

Natural forest (NF): The main plant species in the natural forest are *Apodytes dimidiata*, *Schefflera abyssinica*, *Galiniera saxifraga*, *Syzygium guineense*, and *Ficus sur* and *croton macrostachyus*

Semi managed coffee (SMCF): The main plant species are *Albizia gummifera*, *Acacia abyssinica*, *Croton macrostachyus*, *Cordia Africana* and *Millettia ferruginea.*

Plantation (PLA): The main plant species are *pinus patula*, *Grevillea robusta* and *Eucalyptus camaldulensis*.

Wood land (WL): The main plant species are *Acacia abyssinca*, *Combretum molle, Syzygium guineense, Maesa lanceolata* and *Entada abyssinica*.

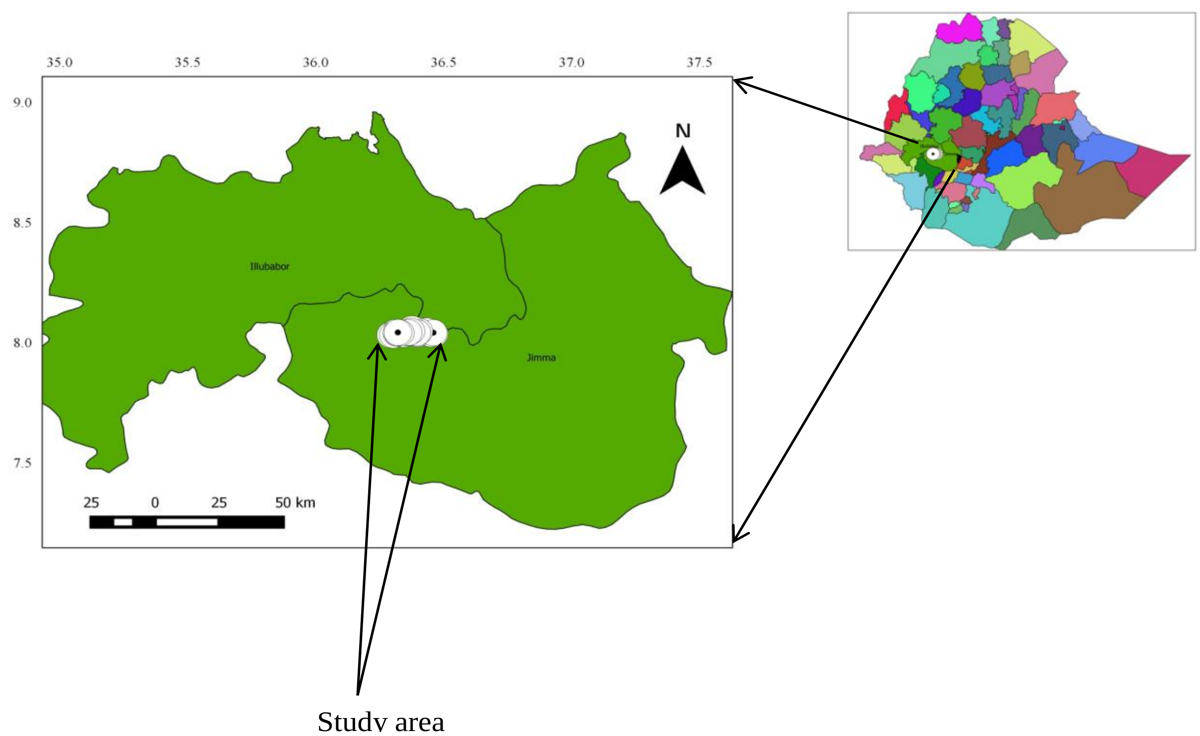

Figure 1. Map of study area

3.3. Butterfly sampling and identification

3.3.1. Transect walk and counts

This study was conducted to document butterfly diversity, abundance and distribution in six different land use Patterns, that were semi managed coffee forest (SMCF), natural forests (NF), wood land (WL), pastureland (PAS), plantation (PL) and cropland (CL) in landscapes of Gumay and Setema districts of Jimma highlands, southwestern Ethiopia along the study transect which connects the two districts. Butterfly collection was made along 20 km transect from 29 hectors of land; each hector was (1 plot).

Special marks such as red flags were used at corners of the plots as landmarks in order to fix borders. Five independent 50m x 5m transects (sub plots) were walked in the centre of each habitat, and all butterflies within 5 m on either side or ahead of the observer were recorded (figure 2).

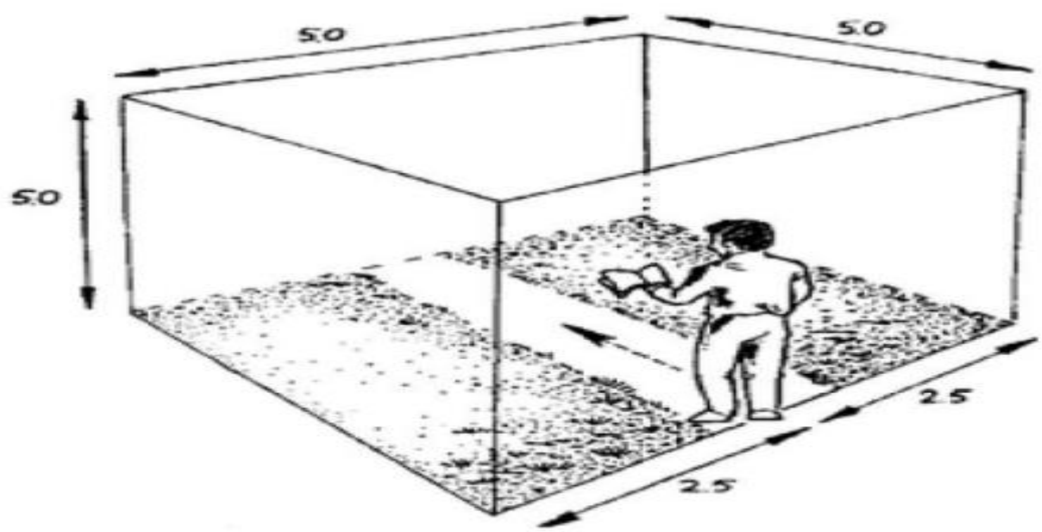

Figure 2. Recorders position during butterflies monitoring in an imaginary box, 2.5m to each side and 5m in front and above.

Each transect line was separated by 25 meters. Transects were positioned in forward and reverse direction. A recorder moved fore and back on the line and around the perimeter of the plot (figure 3).

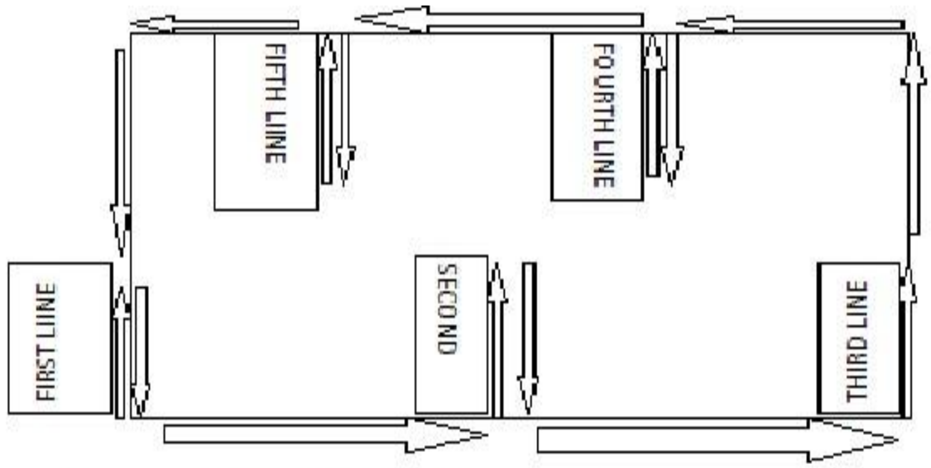

Figure 3. Position OF transect line and walking direction

Transect selection was considered distance, habitat diversity and vegetation cover of the study area. Specific criteria such as disturbed versus stable habitat, land use patterns and accessibility was considered in selection of each transect. Butterfly sweep net of light and strong with fairly open mesh that allows easy swung and insect visibility prepared. A data collecting sheet, clipboard, digital camera, GPS, small plastic envelops; forceps and standard books that help in identification were prepared. At the start of collection, the date and time was recorded. During each sampling visit, butterflies were counted while walking at a steady pace of 5–10 m/min along transect lines, frequently stopping, and observing butterfly species within transect range, took pictures of the butterflies, count number of each butterfly and Photographic documentation was done and the data was maintained.

Butterfly picturing and counting was done first and followed by sweeping (hand Netting). It took on average about an hour and half for each transect. While sampling to both sides of the transect, caution was taken to sufficiently avoid double counting or recounting of individuals of a given species by walking in one direction and by not moving back to resample a species seen behind the surveyor. Thus, during transect walks, specimens were not collected.

Plate 1. Transect walk and recording of individual butterfly (Photo credit: Dinku Arado)

Collections were made for ten days per month for five rounds (first round from 31 December 2014 to 09 January 2015, second round from 26 Jan. to 5 Feb. 2015, third round from 28 March to 6 April 2015 fourth round from 2 May to11 May 2015 and fifth round from 1 June to 10 June 2015) from each transect (Pollard and Yates, 1993).

Transect survey took place between 9:00 am and 4:30 pm (Pollard and Yates 1993) on sunny, windless days as butterfly activity is suppressed on cool, windy or cloudy days.145 sub-plots were set up in six land use patterns.

Species identification was carried out using African butterfly taxonomic key (Willis and Woodhall, 2010; Trevor, F., 2012).

3.3.2. Hand-netting method

Hand-netting was carried out immediately after visual counts finished, using an ordinary insect hand net. Hand-netting was conducted for 20 to 30 min per transect and involved sampling ("hand netting"). All butterflies that could not be identified on-spot during visual censuses were captured and counted.

Plate 2. Hand netting of individual butterfly (Photo credit: Dinku Arado)

Majority of captures were release right away after field identification. Doubtful specimens that could not be identified on the wing characteristics were captured for later identification and put in to transparent plastic envelop individually over silica gel until proper morphological identification was done in the laboratory.

Plate 3. Identification of butterflies in the field (Photo credit: Shumat Tilahun)

3.3. Data analysis

Raw data were recorded in prepared sheets in the field then entered in to computer using Microsoft office excel spreadsheet 2007. the butterfly data collected in the field over the study period was assessed and calculated for each land use patterns, for species richness (the number of species), abundance (the number of individuals) and equitability (evenness) using a diversity indices.

Simpson's Diversity Index was a measure of diversity which takes in to account number of species present, as well as the relative abundance of each species (Simpson, 1948).

$$D = \frac{\Sigma\, n(n-1)}{N(N-1)}$$

n = the total number of organisms of a particular species

N = the total number of organisms of all species

The Shannon diversity index assumes that individuals of each species were randomly sampled from an effectively infinite population. It was calculated from the following equation (Shannon and Wiener, 1949).

$H' = - \Sigma p_i \ln p_i$

The quantity p_i is the proportion of individuals belonging to the $^{i\ th}$ species.

Evenness of butterfly in the study area was calculated using the equation of (Begon *et al*., 1996).

$E = H' / Hmax = H' / \ln S$

The similarity of species composition between land use patterns (Bray-Curtis similarity) was analyzed with cluster analysis using Paleontological Statistics (PAST) Software version 2.17.

To see if there is significant species composition difference among the 6 land use systems Cluster analysis were used for one way ANOSIM.

The spatio-temporal distribution (distribution in space and in time) of butterfly present in the study areas during survey of five months were compared using one-way ANOVA (analysis of variance) and analyzed by means of the Statistical Package for Social Sciences (SPSS) computer Software; version 16.0.Results were presented in the form of tables and figures.

4. Results

A total of 6,993 individuals of butterflies belonging 70 different species and five families were recorded in the study period. Of these 3,200 individual butterflies were recorded under Family Nymphalidae, 2,603 individuals of butterflies were recorded under family Pieridae, 913 individuals under the family Lycanidae, 272 individuals under the family Papilionidae and the list number of individuals of butterflies was recorded under family Hesperidae (only 5) individuals of butterflies (Table 1).

The two dominant species were *Colias electo electo* (959 individuals) and *Bicyclus safitza safitza* (541 individuals). The highest number of individuals of *Colias electo electo* occurred in semi managed coffee forest with 580 individuals and most of the individuals of *Bicyclus safitza safitza* were found with 261 and 128 individuals, in the semi managed coffee and natural forest respectively. The family Nymphalidae was the most dominant in all land use patterns whereas the family Hesperidae was least abundant. Species such as *Acraea acerata, A. lycoa, Charaxes kokloof, Telchinia cerasa* and *Precis octavia sasamus* were recorded only in the natural forest (Appendix II).

Table 1. Butterfly count per month in six different land use pattern in Gumay and Setema districts, southwestern Ethiopia.

Land use pattern	# plots surveyed	Family	Butterfly count per month					Total
			January	February	March	May	June	
Crop Land	6	Nymphalidae	61	46	16	23	23	169
		Pieridae	35	42	26	37	37	177
		Papilionidae						
		Lycanidae						
		Hesperidae						
Natural Forest	4	Nymphalidae	285	199	167	138	144	933
		Pieridae	179	163	126	125	127	720
		Papilionidae	-	-	17	51	51	119
		Lycanidae						
		Hesperidae	-	-	2	-	-	2
Pasture	5	Nymphalidae	9	30	6	27	32	104
		Pieridae	8	6	15	69	69	167
		Papilionidae	-	-	-	1	1	2
		Lycanidae	-	229	-	-	-	229
		Hesperidae						
Plantation	3	Nymphalidae	165	89	93	82	85	514
		Pieridae	109	71	70	50	50	350
		Papilionidae	-	-	11	11	11	33
		Lycanidae						
		Hesperidae	-	3	-	-	-	3
SMCF	7	Nymphalidae	354	244	158	243	243	1242
		Pieridae	321	89	172	231	231	1044
		Papilionidae	-	-	21	44	44	109
		Lycanidae	-	98	10	-	-	108
		Hesperidae						
Wood Land	4	Nymphalidae	32	20	43	71	72	238
		Pieridae	20	2	9	57	57	145
		Papilionidae	-	-	1	4	4	9
		Lycanidae	-	572	4	-	-	576
		Hesperidae	-	-	-	-	-	
Grand total	29		1578	1903	967	1264	1281	6,993

Key: CL: Cropland; NF: Natural forest; PAS: Pasture land; PL: plantation; SMCF: semi managed coffee forest and WL: woodland

Table 2 shows sixty three species were recorded in natural forest followed by the semi managed coffee forest with 56 species. The natural forest was found to be the most diverse habitat in terms of species list, and the cropland was found to be the least diverse (25 species). Species richness index was highest in natural forest (8.3) and lowest in the cropland (4.1). This index was almost similar when comparing woodland and pasture.

Table 2. Diversity indices of butterfly communities in six different land use patterns in Gumay and Setema districts, southwestern Ethiopia.

Land use	Species number(S)	(n)	Species richness index(d) Margalef's	Evenness index (J)	Diversity index (H)
NF	63	1774	8.3	0.89	3.7
SMCF	56	2503	7.0	0.81	3.3
PLA	45	900	6.5	0.80	3.1
WL	34	968	4.8	0.67	2.3
PAS	31	502	4.8	0.74	2.6
CL	25	346	4.1	0.86	2.8
Total		6993			

Key: CL: Cropland; NF: Natural forest; PAS: Pasture land; PL: plantation; SMCF: semi managed coffee forest and WL: woodland.

The evenness index was very high in natural forest (0.89) where there was no any well-known species with high individual number. The high evenness index of the natural forest leads the high diversity index.

Figure 4 indicates that the proportion of Common species (C) and uncommon species (U) tends to decrease from natural forest to the cropland (Appendix II).

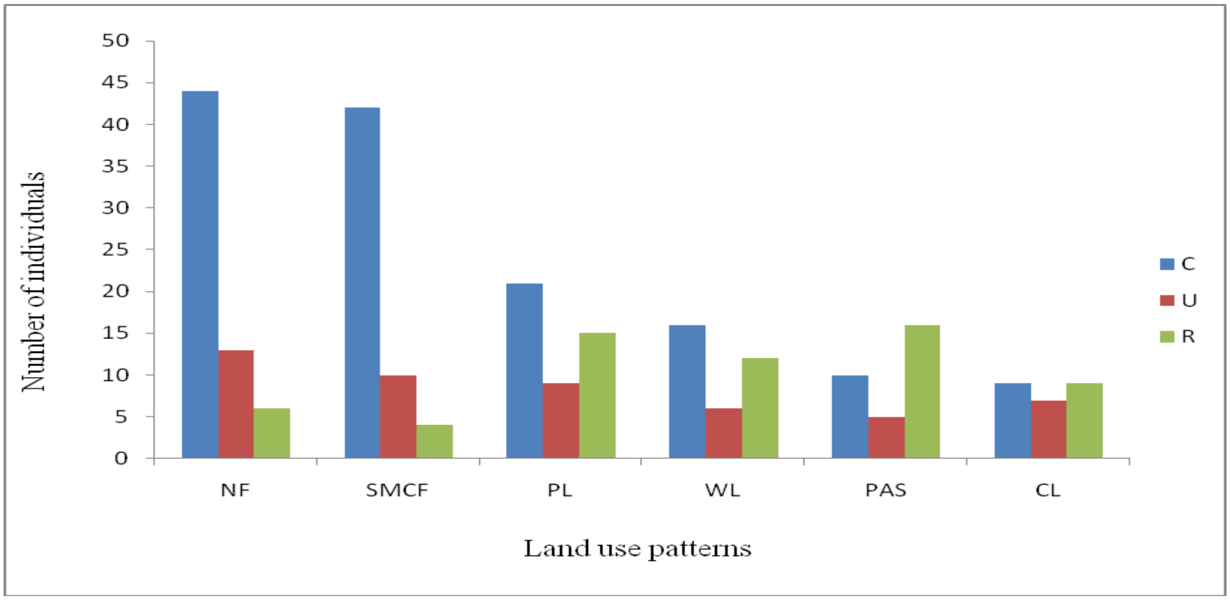

Figure 4. Abundance of butterfly species in each land use pattern in Gumay and Setema districts, southwestern Ethiopia.

Key: CL: Cropland; NF: Natural forest; PAS: Pasture land; PL: plantation; SMCF: semi managed coffee forest; WL: woodland; R: rare species with individuals less than 5; U: uncommon species with individuals from 6 to 10; C: the common species with individuals more than 10.

Table 3 shows that highest mean butterfly density per land use patterns per month was recorded in natural forest (444 individuals). Whereas the least mean butterfly density per land use patterns per month was recorded in cropland (58 individuals). In terms of species richness and abundance of butterflies, the family Nymphalidae was dominant in most land use patterns (610 individuals) whereas the family Hesperidae was least abundant (only 2 individuals.)

Table 3. Mean butterfly density of family per land use patterns per month in Gumay and Setema districts, southwestern Ethiopia.

Land use pattern	# plots surveyed	Family	Mean butterfly count per month per plot					Total
			January	February	March	May	June	
Crop Land	6	Nymphalidae	10.16	7.66	2.66	3.83	3.83	28.16
		Pieridae	5.83	7	4.33	6.16	6.16	29.5
		Papilionidae						
		Lycanidae						
		Hesperidae						
Natural Forest	4	Nymphalidae	71.25	49.75	41.75	34.5	36	233.25
		Pieridae	44.75	40.75	31.5	31.25	31.75	180
		Papilionidae	-	-	4.25	12.75	12.75	29.75
		Lycanidae						
		Hesperidae	-	-	0.5	-	-	0.5
Pasture	5	Nymphalidae	1.8	6	1.2	5.4	6.4	20.8
		Pieridae	1.6	1.2	3	13.8	13.8	33.4
		Papilionidae	-	-	-	0.2	0.2	0.4
		Lycanidae	-	45.8	-	-	-	45.8
		Hesperidae						
Plantation	3	Nymphalidae	55	29.66	31	27.33	28.33	171.33
		Pieridae	36.33	23.66	23.33	16.66	16.66	116.66
		Papilionidae	-	-	3.66	3.66	3.66	11
		Lycanidae						
		Hesperidae	-	1	-	-	-	1
SMCF	7	Nymphalidae	50.57	34.85	22.57	34.71	34.71	177.42
		Pieridae	45.87	12.71	24.57	33	33	149.14
		Papilionidae	-	-	3	6.28	6.28	15.56
		Lycanidae	-	14	1.42	-	-	15.42
		Hesperidae						
Wood Land	4	Nymphalidae	8	5	10.75	17.75	18	59.5
		Pieridae	5	0.5	2.25	14.25	14.25	36.25
		Papilionidae	-	-	0.25	1	1	2.25
		Lycanidae	-	143	1	-	-	144
		Hesperidae	-	-	-	-	-	
Grand total	29		336.16	422.54	212.99	252.63	266.78	1,501

Key: CL: Cropland; NF: Natural forest; PAS: Pasture land; PL: plantation; SMCF: semi managed coffee forest and WL: woodland.

One-way ANOVA were used to compare mean butterfly density among land use patterns (Table4).

All of these variables met the assumptions for ANOVA. There is significant difference of butterfly density among land use patterns (at F= 5.926, P= 0.01). Tukey's Honestly significant difference (HSD) test was used for mean separation to evaluate the statistical significance.

Table 4. Butterfly density per land use patterns per month in Gumay and Setema districts, southwestern Ethiopia.

Land use patterns	Mean ± SE*	95% Confidence interval
NF	89 ± 7.134^{c}	(69.19, 108.81)
CL	11.6 ± 1.691^{a}	(6.90, 16.30)
PAS	19.80 ± 9.041^{ab}	(5.30, 44.90)
SMCF	71.60 ± 7.359^{bc}	(51.17,92.03)
WL	48.4 ± 25.526^{ac}	(22.47, 119.27)
PLA	59.80 ± 8.027^{ac}	(37.51,82.09)

*Means with similar letters in the same column are not statistically significant at 0.05 level.

Key: CL: Cropland; NF: Natural forest; PAS: Pasture land; PLA: plantation; SMCF: semi managed coffee forest and WL: woodland

Table 5 Shows that the natural forest and semi managed coffee forest had all species of the family papilionidae and many species of the family pieridae (≥88.88% species of the family). Natural forest holds all species of family pieridae. Pasture, semi managed coffee forest and woodlands had similar species composition. Natural forest and plantation had similar species composition. Pastureland had all species of Lycanidae (100%). The cropland had the fewest species of all families; Family Nymphalidae and Pieridae were found in all six land use patterns in different proportion.

Table 5. Mean percentage butterfly family in six different land use patterns in Gumay and Setema districts, southwestern Ethiopia.

Family	♯ of spp.	Land use patterns					
		CL	NF	PAS	PLA	SMCF	WL
Hesperidae	1	0.00	100.00	0.00	100.00	0.00	0.00
Lycanidae	2	0.00	0.00	100.00	0.00	100.00	100.00
Papilionidae	5	0.00	100.00	20.00	60.00	100.00	40.00
Nymphalidae	44	30.00	91.00	39.00	60.00	75.00	48.00
Pieridae	18	61.00	94.00	61.00	83.00	89.00	50.00

Key: CL: Cropland; NF: Natural forest; PAS: Pasture land; PL: plantation; SMCF: semi managed coffee forest and WL: woodland

4.1 Similarity analysis

Table 6 shows butterfly species similarity was highest between the SMCF and PLA (S=93%), and least between the NF and PAS (S=20%).

Table 6. Bray- Curtis Similarity and distance indices for butterfly communities in six different land use patterns in Gumay and Setema districts, southwestern Ethiopia.

Land use patterns	CL	NF	PAS	PLA	SMCF	WL
CL	1					
NF	0.24	1				
PAS	0.90	0.20	1			
PLA	0.33	0.81	0.31	1		
SMCF	0.30	0.86	0.31	0.93	1	
WL	0.75	0.29	0.59	0.49	0.38	1

Key: CL: Cropland; NF: Natural forest; PAS: Pasture land; PL: plantation; SMCF: semi managed coffee forest and WL: woodland

The butterfly species similarity among the six land use patterns was (32 %) (Figure 5). Furthermore, pasture, cropland and woodland showed 68 % similarity and the natural forest, semi managed coffee forest and plantation forest group were found to be 82% similar.

One way ANOSIM results showed that species difference among the six land use pattern was not significant (Brey-Curtis test, R = 1.067, P = 1).

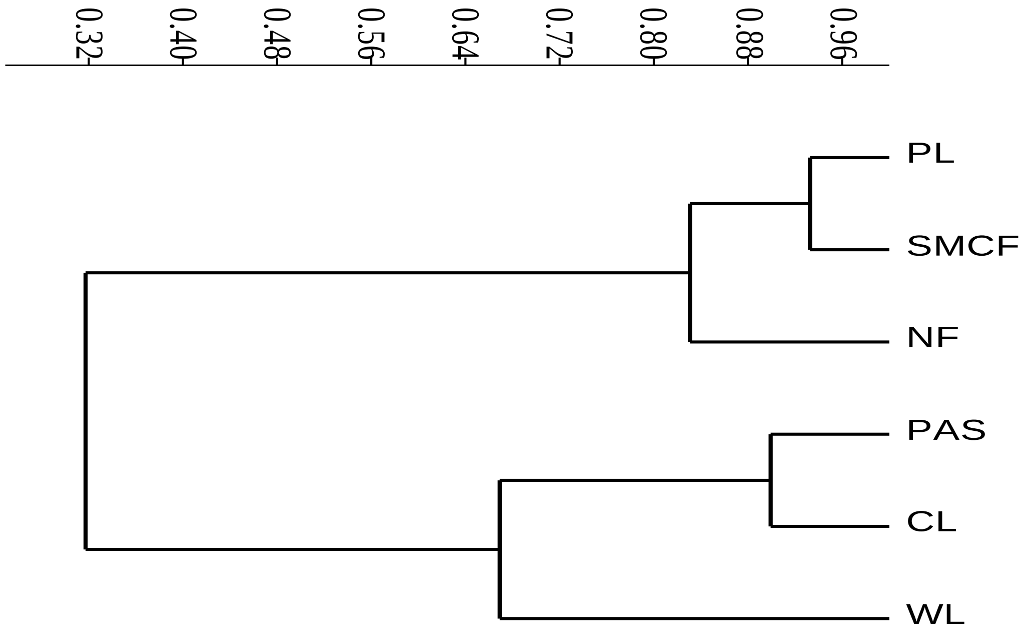

Figure 5. Species similarity among six land use patterns in Gumay and Setema districts, southwestern Ethiopia.

Key: CL: Cropland; NF: Natural forest; PAS: Pasture land; PL: plantation; SMCF: semi managed coffee forest and WL: woodland.

The two most common families, Pieridae and Nymphalidae among the six land use patterns were further analyzed in order to determine the relative distribution among land use patterns by cluster analysis of similarity and presented in (Table 7).

Table 7. Bray - Curtis similarity and distance indices for butterfly familiy of Peridae and Nymphalidae in the six different land use patterns in Gumay and Setema districts, southwestern Ethiopia.

Land use	CL	NF	PAS	PLA	SMCF	WL
CL	1					
NF	0.24	1				
PAS	0.90	0.23	1			
PLA	0.33	0.82	0.32	1		
SMCF	0.30	0.88	0.28	0.94	1	
WL	0.75	0.38	0.72	0.50	0.45	1

Key: CL: Cropland; NF: Natural forest; PAS: Pasture land; PL: plantation; SMCF: semi managed coffee forest and WL: woodland.

Figure 6 shows that the similarity of species of family pieridae and nymphalidae was highest among land use patterns of Plantation, natural forest and semi managed coffee forest (84%) followed by Pasture, Woodland and cropland (72 %).

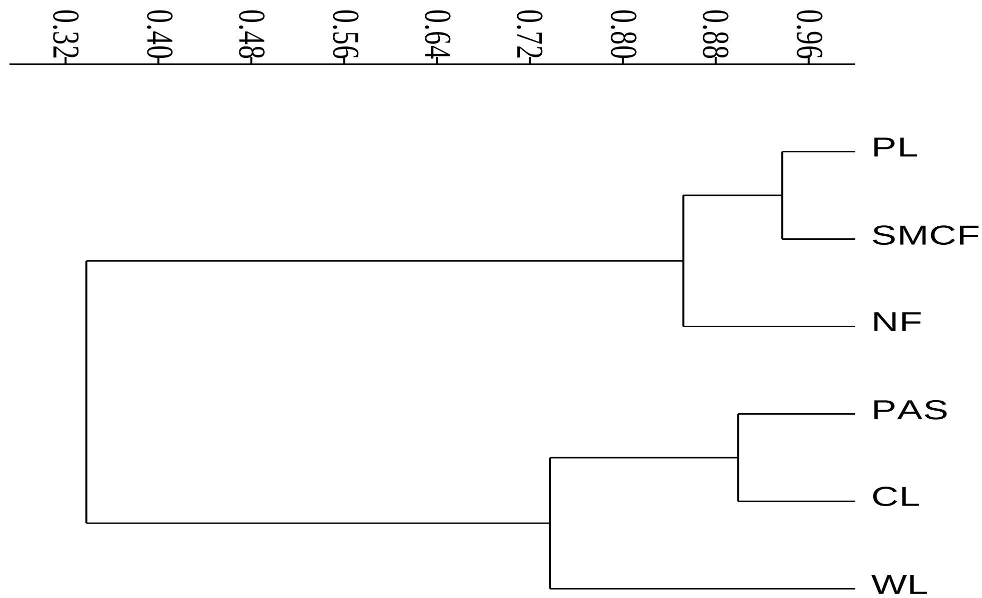

Figure 6. Species similarity of familiy Peridae and Nymphalidae among the six land use patterns in Gumay and Setema districts, southwestern Ethiopia.

Key: CL: Cropland; NF: Natural forest; PAS: Pasture land; PL: plantation; SMCF: semi managed coffee forest and WL: woodland.

4.2 Monthly butterfly dynamics

Figure 7 shows that a total of 6,993 individuals of butterflies under five families and 70 species were recorded in six different land use patterns. Out of these, 1571 individuals of butterflies collected in the first round from 31Dec 2014 to 9 Jan.2015, 1903 individuals of butterflies were recorded in the second round from 26 Jan to 5 Feb. 2015, 967 individuals of butterflies were in the third round from 26 March to 6 April 2015, 1264 individuals of butterflies were recorded in the fourth round from 2 May to 11 May 2015 and 1281 individuals of butterflies was recorded in the fifth round from 1 June to 10 June 2015 (Appendix III).

Figure 7 shows monthly survey of butterfly number of species and individuals collected in six different land use patterns from Gumay and Setema districts, southwestern of Ethiopia. We can infer that the family Nymphalidae and Pieridae were found year round and their abundance decreases from January to March and again increases from March to June. The best month of flight for Family Lycanidae was February and they reach peak in February and diminishing in the following months. Flight period of Family Papilionidea was year round and they were equally abundant in May and June (111- individuals). Family Hesperidae was not common during the study period from January 2015 to June 2015 (Appendix III).

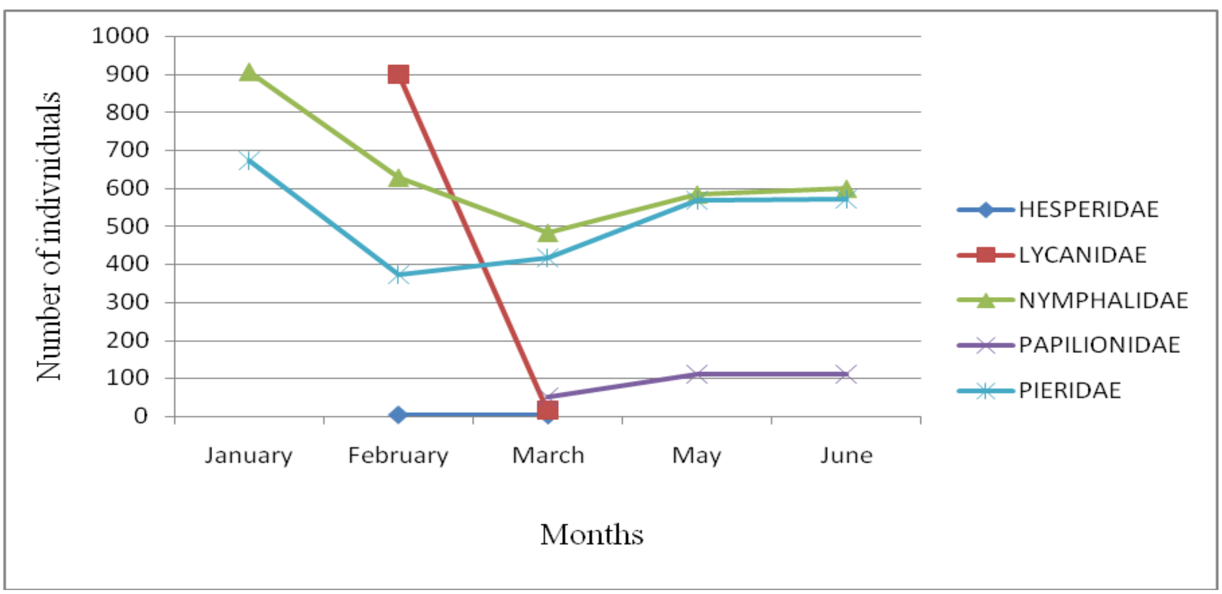

Figure 7. Monthly butterfly dynamics for five families collected from Gumay and Setema districts, southwestern Ethiopia.

We used one-way ANOVA to evaluate differences of butterfly abundance among months (In) adjusted (all of these variables met the assumptions for ANOVA). Tukey's Honestly significant difference (HSD) test was used to evaluate the statistical significance of these differences.

There was high significant difference of butterfly diversity and abundance among months (at F= 6.22, P= 0.000).

Mean butterfly abundance and species density were highest in the first two months (January and February) (Table 8). Although the pair wise comparison of butterfly species density between these two months were significant. Slightly lower mean abundances were found in the last three months (March, May and June). None of the pair wise comparisons of butterfly species density among these three months were statistically significant (Tukey's HSD test, $\alpha = 0.05$), although the model as a whole were significant.

Table 8. Mean density of butterfly per month in Gumay and Setema districts, southwestern Ethiopia.

Month	Mean ± SE*	95% Confidence interval
January	15.03 ± 1.160^{a}	(12.73, 17.33)
February	8.81 ± 1.165^{b}	(6.51, 11.11)
March	4.88 ± 0.338^{c}	(4.22, 5.55)
May	4.30 ± 0.315^{c}	(3.68, 4.92)
June	4.19 ± 0.305^{c}	(3.59, 4.79)

*Means with the same letter in the same column are not statistically significant at 0.05 level.

5. Discussion

Butterfly diversity, abundance and species richness were studied in six different land use patterns within Setema and Gumay districts of Jimma zone southwestern Ethiopia. During the surveys, the natural forest had the highest number of species (63) followed by semi managed coffee forest (56), plantation forest (45), wood land (34), Pasture land (31) and crop land (25). This was similar to other studies showing that the forest had more butterfly species than shrub, grass habitats and agricultural lands (Lien and Yuan, 2003; Vu, 2008, 2009).

Butterfly count per plot per month of natural forest was 444, semi managed coffee forest 358, plantation 300, woodland 242, pasture 100 and cropland was 58. And study confirms that the number of species and number of individuals was high in the natural forest and then declined in the grassy shrub patch and crop land (Ogedegbe *et al*., 2014). An important factor behind butterfly losses was the loss of flower-rich habitats from crop land (Nilsson *et al*., 2008).

In terms of both species richness and abundance of butterflies, the family Nymphalidae was the most dominant in all land use patterns. For example, of total 1,501 mean abundance of individuals during the study periods per plot per month 691 individuals were recorded from nymphalidae. Of these 233 individuals from natural forest, 177 individuals from semi managed coffee forest, 171 individuals from plantation, 60 individuals from woodland, 29 individuals from cropland and 21 individuals of Nymphalidae from pasture. Overall species abundance and richness revealed that Nymphalidae was the most specious and individualized family and Hesperidae was the least specious and individualized family in the study area. In the context of tropical environment, similar patterns of species abundance and richness were reported from the Western Ghats and western coast of India (Padhye *et al*., 2006; Krishnakumar *et al*., 2007 and Raut and Pendharkar, 2010). In addition to these Pre-dominance of Nymphalidae was also reported by different researchers (McCulloughet *et al*., 2007; Sundufu and Dumbuya, 2008; Dolia *et al*., 2008; Kunte, 2008; Humpden and Nathan, 2010).

According to the niche-breadth-theory, species with a greater degree of generalization are more likely to also have a wider geographical distribution (Brown, 1984). Although the theory has been criticized for lack of evidence, recent studies of butterflies in both tropical and temperate regions have revealed strong positive relationships between geographical range and host plant range (Quinn *et al*.,1997; Benedick *et al*., 2006; Charrette *et al*., 2006;). A link has also been placed between the extent of distribution within the native range and the ability to colonize foreign areas (Charrette *et al*., 2006). The butterfly larvae are chiefly herbivorous (Hamer *et al*., 2006), displaying either monophagy (here defined as feeding on only one family of plants) or polyphagy (here defined as feeding on several families of plants). The presence of larval host plants has been linked to butterfly diversity (Koh and Sodhi, 2004). In the present study, the dominance of Nymphalidae species attributed to their being polyphagous, which helps these butterflies to live in a variety of land use patterns, and also because many species of this family are active fliers, which helps them to forage larger areas. However, in the present study, members of Hesperiidae to be least represented. One of the possible reasons for this difference could be due to the difficulties in observing Hesperiidae butterflies because of their dull color and ability to fly rapidly following any disturbance (Majumder *et al*., 2013) (Table 3).

Species such as *Acraea acerata, A.lycoa, Charaxes kokloof, Telchinia cerasa* and *Precis octavia sasamus* were recorded only in the natural forest (Appendix 2). The continuous presence of these species in the natural forest shows that may be the forest still provides favorable conditions and resources for them and undisturbed. And also we can possibly wind up monophagous and sedentary butterfly species, being the most threatened, will require increased attention in the future by conservation biologists (Boggs and Murphy1997). Although diverse plants and access to plants promote the butterfly richness and density, our study shows a very different ecological conditions is required in some of the endangered species within the community. This highlights a need for considering each species' particular requirements and ecology. The results indicate that sole consideration of the priorities of butterfly communities could lead to imperfect management, especially when generalist species are more abundant. Significant conditions and conservation statuses of locally endangered species should be carefully considered in order to implement effective management and restoration practices (Ochoa-Hueso *et al*., 2014).

Margalef's index had allowed evaluating and comparing possible differences in species richness among the six land use patterns during the sampling periods. Natural forest was the richest habitat (8.3) these values were probably influenced by the presence of food resources for larva and adults, the exposure of the size to the wind, sunlight and plant. Cropland was the poorest habitat (4.1) this last factor was likely to be the absence of food resources for larva and adults found in cropland. In addition, the result of Brey – Curtis similarity index of butterfly indicates that cropland and natural forest shared very small similarity of butterfly species (0.24%).

Butterfly abundance depended significantly on vegetation characteristics, indicating that areas with high plant resources supported more butterflies. The structural complexity of habitat and diversity of vegetation forms have been shown to be correlated with animal and insect species diversity (Gardner *et al*., 1995). Southwood (1975) suggested that the herbivores were more influenced by the food quality. Host plants were utilized only when sufficient adult resources (nectar) were also available (Grossmueller and Lederhouse, 1987). Successful butterfly habitat must therefore include sufficient larval and adult food resources. Hence, the decline and abundance of butterflies in many ecosystems is directly proportional to the type and abundance plant growth in the area. The less diversity of vegetation results with less diversity of butterflies. Studies also show that the more diverse plants are the more diverse butterflies and insects are (Spitzer *et al*., 1987; Devries, 1992).

In the present study, the maximum number of species and individuals were observed in natural forest and semi managed coffee forest, where availability of diverse plants and access to plants promote the butterfly richness and density. Thus, the relatively low abundance of butterflies in cropland compared to the other land use patterns may be due to less resource provided by the cropland. The cropland had the most open species and almost all forest species were absent from this land use pattern. This result is in agreement with other studies of butterfly distributions (Brown, 1996; Blair and Launer, 1997). The result of this study shows the importance of plant resources in influencing butterfly abundance. The result also highlighted the importance of protection of natural forests in Gumay and Setema districts, southwest Ethiopia to conserve butterfly biodiversity. Several studies indicate that farmland habitats support poor communities of butterflies (Fitzherbert *et al*., 2006). In this study, it was observed that sites of pastureland, woodland and cropland had the least species richness index compared to natural forest; semi managed coffee forest and plantation.

Natural forest was richer in species abundance of common species and these decreased with habitat opening levels from natural forest to the cropland. This was true for uncommon species also (Figure 4). The result was similar with a study conducted in Vietnam where a similar pattern of abundance of common species and uncommon species distribution (Vu and Vu, 2011).

In this study, the species composition was not similar among all land use patterns, but rather similar among pasture, semi managed coffee forest and woodland; As well as between natural forest and plantation. Habitat of coffee forest, woodland and Pasture were not much similar but all species found in the coffee forest were also found in the woodland and pastureland. For instance family Nymphalidae and family pieridae were found in these land use patterns. These butterflies fly near the ground. Thus, in this study the species composition of the coffee forest, woodland and pastureland was similar; the species composition of the plantation and natural forest was also rather similar (for example family Papilionidae). These butterflies fly high above the ground. The butterfly species composition differed between land use patterns, the findings were similar with the findings of other similar studies conducted elsewhere (Dewenter and Tscharntke, 1997; Vu, 2009).

The findings of this study indicated that natural forest and semi managed coffee forest was more valuable for butterfly conservation. From our study butterfly diversity and abundance were highest in the first two months (January and February), although the pair wise comparison of butterfly species density between these two months were significant. Slightly lower abundances were found in the last three months (March, May and June). None of the pair wise comparisons of butterfly species density among these three months were statistically significant (Tukey's HSD test, $\alpha = 0.05$). This is may be because of precipitation and vegetation indices. Overall butterfly species richness and density varied seasonally. It is likely that seasonal change in species richness and density of butterflies may be attributed to monthly variation in climatic factors such as temperature and precipitation. The seasonality in butterfly species occurrence tended not to follow very closely the general patterns of rainfall in the study area. However, peak in butterfly species richness appeared to coincide with peaks in the availability precipitation and butterfly food plants such as the presence of flowers. Habitat association of butterflies can be directly related to the availability of food plants (Thomas, 1995).

6. Conclusion and Recommendations

6.1. Conclusion

This study revealed that butterfly diversity and abundance were higher in natural forest; semi managed coffee forest and plantation forest while they were lower in woodland, pasture and cropland. Species richness and evenness was highest in natural forest and lowest in woodland and pasture. Moreover, butterfly diversity and abundance were significantly related with plant species richness, plant species diversity and plant species abundance suggesting the important role of vegetation in determining butterfly survival in the forest. From the current study butterfly species similarity was highest in the semi managed coffee forest and plantation forest and least in the pasture and natural forest. There was significant association among months and butterfly diversity and months and butterfly abundance in Gumay and Setema districts of Jimma zone of southwestern Ethiopia.

6.2. Recommendations

Even though there was significant difference in butterfly diversity, abundance and distribution during the five months, it would be desirable if such studies could be done on regular basis in the study area for a year or more than a year. Then comparing the data will give us interesting results about the differences of butterfly abundance, diversity and distribution with absolutely different climatic conditions. Although, the data collection time was short during this study supplied valuable information about the diversity, abundance and distribution of butterflies in natural forest and semi managed coffee forest of Gumay and Setema districts of Jima zone, southwestern Ethiopia. Hence, due to the importance of vegetation to butterflies by means of provision of resources and habitats, it is essential for forests to be conserved so as to maintain butterfly diversity and abundance.

Based on the significant effects of forest on butterfly community in this study, the following are recommended:

- Further study should be conducted in the rainy and dry seasons to examine the influence of seasonality on butterfly community in the study area.

- ❖ Further research is needed in order to discover which plant species are preferred sources of nectar for butterflies over a longer time frame.

- ❖ Butterflies require a healthy environment in order to survive and there are a number of ways in which we can help, for example:

- By planting native host plants on which females can lay their eggs,
- By planting native plants with nectar-producing flowers on which adults can feed,
- By providing water for adults in hot dry weather,
- By restricting clearance of native vegetation and by restricting use of herbicides and insecticides etc.

- ❖ There is a need for giving conservation education to the local communities on the importance of conserving biodiversity resource and to protect the Gumay and Setema districts forest reserve from destruction. This can be done through the establishment of educational groups such as nongovernmental organizations that will be concerned with forest conservation. Also government of Ethiopia should organize regular meetings for people of Gumay and Setema districts and also encourage them for their participation in the conservation programmes.

- ❖ In order to ensure the sustainable protection of the Gumay and Setema districts natural forest, there must be implementation of management plans of protection that will be collaborative approach between forests and wild life commission of Oromia regional state, the public and private sectors, in order not to allow the forest commission only protects the forest. These measures will enhance strong security in and around Gumay and Setema districts forest reserve.

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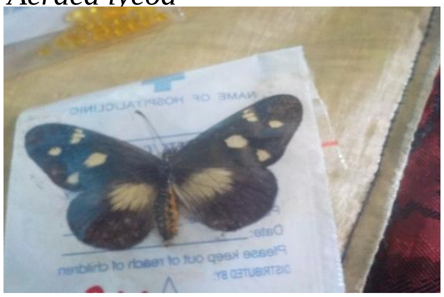
Appendix I

Acraea lycoa



Acraea horta

Danaus chrysippus

Bicyclus safi tza safi tza

Libythea labdaca laius

Junonia oenone oenone

Neptis goochii

Neptis leata

Phalanta phalanta eurytis

Protogoniomorpha parhassus

Sevenia boisduvali boisduvali

Tirumala hamata

Vanessa dimorphica dimorphica

Papilio dardanus Africa

Papilio demodocus demodocus

Papilio Euphranor

Belenois creone severina

***B**elenois gidica abysinica*

Belenois raffrayi extendens

Colias electo electo

Mylothris agathina agathina

Appendix II

SCIENTIFIC	Cropland	Forest	Pasture	Plantation	SMCF	Woodland	Grand Total
Acraea acara		38	2	11	8	2	61
Acraea acerata		8					8
Acraea aganice		27		4			31
Acraea alicope		9			2		11
Acraea cabira		17		3			20
Acraea horta	2	24		4			30
Acraea lycoa		14					14
Acraea lycota		10	2		6		18
Amauris albimaculata maculata					8		8
Amauris echeria echeria		6			35	4	45
Amauris ochlea ochlea		11		2	18		31
Belenois aurota aurota	34	32	20	17	8	12	123
Belenois creone severina	6	39	34	10	37	16	142
Belenois gidica abyssinica	58	38	32	6	8	36	178
Belenois raffrayi extendens		10			14		24
Belenois zochalia zochalia	17	42	41	16	19	15	150
Bicyclus anynana anynana		59		111	57	33	260
Bicyclus safitza safitza	9	128		115	261	28	541
Candalides erinus			115		46	253	414
Candalides hyacinthina			114		62	323	499
Catopsilia fiorella		28		2	3		33
Catopsilia gorgophone	7	7		9			23
Catopsilia pomona		20	4	6	16	6	52
Charaxes brutus natalensis	4	3	2	8	8		25
Charaxes karkloof		2					2
Colias electo electo	3	168	2	166	580	40	959
Colias eurytheme	31		4		12		47
Danaus chrysippus orientis		12	4	7	12		35
Eurema brigitta brigitta	4	23		27	20		74
Eurema desjardinsii marshalli		39		14	19		72

Appendix II continued

SCIENTIFIC	Cropland	Forest	Pasture	Plantation	SMCF	Woodland	Grand Total
Eurema hecabe solifera	3	138	7	54	76	10	288
Eurema lisa		17		2	23		42
Eurytela drope angulata		4			13	9	26
Graphium leonidas leonidas		6			4		10
Heteronympha minifera	6	22	2	18	25	10	83
Hypolimnas anthedon wahlberg	6	16	10	2	29	4	67
Hypolimnas misippus		12	2		10	1	25
Junonia hierta cebrene			1				1
Junonia oenone oenone	35		2		4	12	53
Junonia terea elgiva		38	7	21		18	84
Leptosia alcesta inalcesta		10		24	35	2	71
Libythea labdaca laius		13		21	13		47
Melanitis leda helena	38	6		6	34	16	100
Metisella orientalis orientalis		2		3			5
Mylothris rueppellii haemus	8	26	16	15	104	8	177
Neptis goochii		51	12	2	68	5	138
Neptis laeta		68	10	12	112	14	216
Neptis scalva marpessa		23	4	1	35	4	67
Papilio dardanus africa		75		9	53		137
Papilio demodocus demodocus		6			8	4	18
Papilio euphranor		10		14	12		36
Papilio nireus lyaeus		22	2	10	32	5	71
Phalanta phalanta aethiopica		14	17	2	51	10	94
Phalanta phalanta eurytis	6	10	20		52	17	105
Pieris brassicae	4	49	5	4	79	2	143
Pieris rapae	2	15	2	2	26		47
Precis octavia sasamus		29					29
Protogoniomorpha anacardii nebulosa		14		18	34	2	68

Appendix II continued

SCIENTIFIC	Cropland	Forest	Pasture	Plantation	SMCF	Woodland	Grand Total
Protogoniomorpha parhassus		7		22	15		44
Sevenia boisduvali boisduvali		3		5	43		51
Telchinia anacreon		15		4			19
Telchinia cerasa cerasa		2					2
Telchinia encedon		15			10		25
Telchinia esebria		76			25		101
Telchinia rahira	13				19		32
Telchinia serena	5	60			9		74
Tirumala hamata		14			16		30
Vanessa dimorphica dimorphica	2	18	1	24		1	46
Ypthima asterope	17	25		39	80	20	181
Ypthima impura	26	29	6	28	95	26	210
Grand Total	346	1774	502	900	2503	968	6993

Appendix III

Monthly butterfly dynamics for five families collected from Gumay and Setema districts, Southwestern Ethiopia.

Month	Hesperidae	Lycanidae	Nymphalidae	Papilionidae	Pieridae	Grand Total
January			906		672	1578
February	3	899	628		373	1903
March	2	14	483	50	418	967
May			584	111	569	1264
June			599	111	571	1281
Grand Total	5	913	3200	272	2603	6993