Butterfly assemblages of forest, grassland and disturbed ecotones near Goba, southern Mozambique

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To Victoria, my wife
And my daughter Daisy

Summary

Transect surveys of adult butterflies and diurnal moths were conducted at seven study sites in Goba-Maputo, southern Mozambique. Four hundred and fifty individuals representing 83 lepidoptera species were recorded. Species composition and ecological indices (similarity, richness, dominance and diversity) were calculated for total and specialist species. Forest, with more than 80% canopy cover with height greater than 2 meters has the lowest species richness. Three species were restricted to forest. Grasslands showed greater canopy cover for the vegetation less than 0.5 meter high, and ranked second on lepidopteran species diversity. The forest edges with more than 50% of canopy cover of a mixture of middle-sized trees, between 1 and 2 m, has the highest species richness.

Charaxes candiope was the dominant species in the study area. However *Hamanumida daedalus*, *Bicyclus safitza safitza*, *Charaxes jasius saturnus* an *Catacroptera cloanthe cloante* were the most dominante species in Apiario grassland (G), Mandimbe edge (E), Mbilambi forest (F) and Movene grassland (G). Grassland and forest edges shared more species than forest and disturbed forest edge. Most forest species avoided forest edges and/or grassland indicating that they are probably more sensitive to fragmentation and edges. Thus, the results show that fragmentation generally increases species diversity (forest edges contained the greatest species richness). However in the long term, habitat disruption can reduce overall species diversity, reducing species with low geographic ranges and forest endemics, whilst gaining generalist species. For conservation purpose core areas of the forest should be preserved, a measure which would protect other (uncensured) species.

1. Introduction

Habitat loss and degradation are major causes of biodiversity decline (Hobbs, 1993; Dale *et al.*, 1994). However, changes in ecosystem processes and functions associated with habitat loss are difficult, or very often inconvenient, to measure or quantify. Subtle or complex environmental trends can be assessed by using factors that are ease to score, but can be correlated to difficult ones (de la Maza, 1998). One approach that has been used in environment assessment is the use of indicator species or bioindicators. A bioindicator is a species which can easily be characterised by indices of attributes which, can then be correlated to environmental or habitat parameters. For example, lepidopterans are generally very sensitive to habitat change or fragmentation due to their dependence on specific foodplants. They have been used successfully as indicators of habitat fragmentation (Haddad, 1999), as they are easy to sample and have exacting habitat requirements.

In the broader conservation context, it has been suggested that insects may prove to be appropriate targets as part of the environment impact assessment since they have close and often extremely precise relationships with their foodplants. Butterflies in particular are thought to be excellent environmental indicators (Launer and Murphy 1994; Wood and Gillman, 1998). The dependence of the larval stage on a specific host plant, combined with the adults' roles as pollinators for other plants, links butterflies to the ecological health of their habitat. Butterflies are also a most popular order of insects among the general public, and as such are important flagships for the public perception of invertebrate conservation. Further perceived importance of the group derives from the threatened status of numerous species (Wood and Samways, 1991).

The creation of vegetation gaps in forest habitats by local people changes the natural disturbance pattern and threatens biota confined to the closed canopy. The gaps formed by woodcutting are larger and are formed at a higher rate than those developing under natural conditions. Usually butterflies in closed rain forest are highly sensitive to even small-localised damage (Spitzer *et al.,* 1997).

The aim of this study was to document the lepidoptera species composition, abundance and richness, with special reference to butterflies and diurnal moths, of a series of contrasting habitats in Goba, Maputo, Mozambique. The study set out to provide baseline data against which to evaluate the effect of human disturbance such as grazing by livestock, or removal of trees for fuelwood or timber on forest and grassland. Different habitat types: forest, grassland and disturbed forest edge were assessed. The hypothesis is that the forest edges representing intermediate or disturbed habitats, would have greater lepidoptera community diversity and abundance than core areas of the forest and natural grassland, thus supporting the intermediate disturbance hypothesis (Swengel, 1998). Forest core areas and grassland are expected to have species restricted to one or other of these habitat types.

Butterflies were chosen because they are taxonomically well known, and many species can be identified in the field. Butterflies are also very sensitive to environment change such as temperature, humidity and light level, parameters that are affected by the type of habitat (Wood and Gillman, 1998).

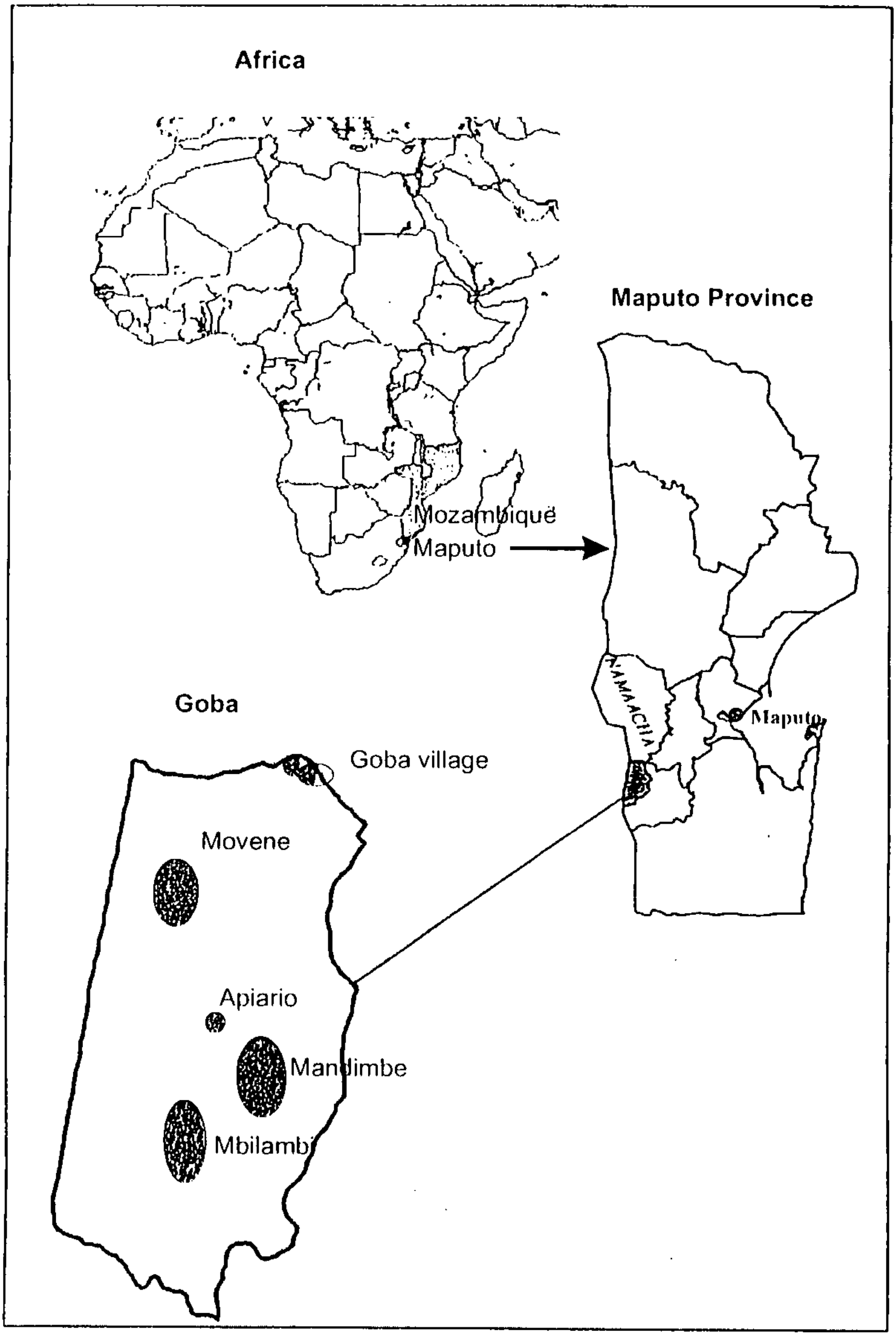
2. Methods

2.1. Study area

Goba is situated 60 km southwest of Maputo Province, Namaacha district, close to the Swaziland border (Figure 1). The geology of Goba consists of rhyolite which gives shallow soils that are classified as lithosols (Mafalacusser *et al.*, 1999; Low and Rebelo, 1996). The altitude of the area varies from 100 to 600 m above sea level. The average annual rainfall ranges from 600 to 800 mm (DPAPPM/SPFFB, 1998; Low and Rebelo, 1996). The summer rainy season starts in October and ends in March. Winters are dry and frost free. The average annual temperature is 21.5°C, the lowest temperature being recorded in July (13.1°C), and the average maximum temperature of 30.1°C occurring in January. (Mafalacusser *et al.*, 1999)

The vegetation is a part of Lebombo Arid Mountain Bushveld with *Combretum apiculatum, Androstachys jonhsonii*, *Stychnos madacasruensis*, *Spirostachys africana*, *Pterocarpus rotundifolius* and *Sclerocarya birrea* being the dominant species (Low and Rebelo, 1996; DPAPPM/SPFFB, 1998).

Collection of forest resources, for local use and trading in Maputo, is a principal source of income for the inhabitants of Goba village, resulting in extensive forest fragmentation (Mafalacusser *et al.*, 1999). The original forest has been reduced due to human activities such as logging, charcoal production and shifting cultivation. The degraded areas consist of about between 100 and 200 meters (from the edge of the original forest boundaries) which became forest edges as a result of selective logging of species with local value. This process is worse on the forest boundaries due the easy access. However, small patches of forest in inaccessible mountain area still remain, but are vulnerable as some villagers have been trying to explore these "rich"



Adapted from Mafalacusser *et al.* 1999

Figure 1. African Map showing Mozambique, Maputo and the study area.

areas not only for timber but also for collection of medical plants. Burning is a common method to prepare arable land for cropping, moreover, uncontrolled fire often escapes from the charcoal "production centres", causing a lot of damage to either grasslands or other vegetation's type.

Recently, the community realised the damage of unsustainable use of their natural resources and set up their own management project called "Ntava Yedzu" (Ronga words for "Our Mountain") funded by FAO. The project aims are to find an alternative management strategy to save and regenerate the original forest. Ecotourism is one of the alternatives that a being considered to avoid natural resource degradation (MADR/DPADR/SPFFB, 2000). The ecotourism alternative is applicable in Goba due to the natural beauty and diversity of landscape in the Lebombo escarpment and its riverine system of Umbeluzi and Changalane rivers. Goba is pproximately 10,000 ha and is considered to be a partially protected area (Mafalacusser *et al.*, 1999). Goba also forms part of Spatial Development Initiative (SDI) signed by Mozambique, South Africa and Swaziland as a part of Lebombo development protocol in order to boost ecotourism and agriculture and reduce natural resources degradation on transfrontier areas/zones of the three countries.

Studies in vegetation and mammal diversity have been done in the past (DPAPPM/SPFFB, 1998) but this was the first butterfly census to be done in Goba. Goba has the advantage of having diverse landscapes in a small area, which makes it a good target for study. This study will contribute to planning of ecotourism, which is an alternative source of income for the local community.

2.2. Census

2.2.1. Lepidoptera

The census targeted understorey butterflies and diurnal moths. Fieldwork took place between 18 September and 20 October 2000. The survey was done on sunny days with cloud cover mostly less than 50%, as is well known that butterfly activity is suppressed on cool and cloudy days in tropics and subtropics regions (Wood and Samways 1991). The activity of butterflies is high during wet season (Hill, 1995), and the period within which the study was carried out was reasonably wet.

Seven sites were selected for the study. Two forest sites were used, Mandimbe F (forest) and Mbilambi F (forest) and their respective edges with woodland Mandimbe E (edge), Mbilambi E (edge) were sampled. Grassland, Movene G (grassland), and its edges with woodland, Movene E (edge), were used. A single burned isolated grassland, Apiario G (grassland) was used as a contrast. The burn took place two months before the survey and patches of vegetation types typical of local grassland remained and some grass was already starting to resprout. Scarce matrix vegetation consisting of patches of thick *Androstachys jonhsonii*, open woodland and bushveld surrounding forest, and some cultivated and abandoned small farm patches surrounding grasslands were not sampled.

Within each site one, 100 m-long, fixed-strip transect was walked twice a day, for 20 days (following the methods of Natuhara *et al.*, 1998; Hill, 1995; Wood and Gillman, 1998): in the morning between 8:30-11:00, and in the afternoon 14:30-17:00. This is the period when butterflies are most active (Wood and Samways 1991). Two observers walked 5 meters apart with a net, trying to catch or identify all butterflies in the strip of 5 meters on both sides and 5 meters high as standard recommendation in butterfly studies (Wood and Gillman, 1998). To avoid bias in the result different transects were walked in different times of the day (Natuhara *et al.*, 1998).

Hand netting was supplemented with fruit traps in order to collect understorey fruit feeding butterfly species (Wood and Gillman, 1998), as described by Migdoll (1992). Three fruit traps were located within all transects. They were located 30 meters apart and were checked at two hourly intervals.

2.2.2. Vegetation

Vegetation structure and cover were estimated at 20 meter intervals within the chosen transects. Percentage of canopy cover in the quadrats was estimated in height classes of: < 0.5, 0.5 – 1, 1 – 2 and > 2 meters (Myers and Shelton, 1980).

2.2.3. Species identification

Butterflies and diurnal moths were identified tentatively in the field using Williams (1994), Migdoll (1992) and Pinhey (1974) if their identity was unambiguous. Representatives of each species were collected for subsequent confirmation in the laboratory using Dickson and Kroon (1978). The resulting butterfly collection will be donated to the National Museum in Maputo (Museu Nacional de Historia Natural).

2.3. Data analysis

The following similarity, diversity and abundance indices (as given in Southwood (1995)) were used to describe butterfly and vegetation composition:

a) Bray-Curtis coefficient of similarity

$$C_N = \frac{2jN}{aN + bN}$$

where: aN = the total individuals sampled (N_T) in habitat a

bN = the total individuals sampled (N_T) in habitat b

jN = the sum of the lesser values for the species common to both habitats

b) Species richness:

Total lepidoptera community richness was calculated using the sum of all species recorded (as one or more individuals) caught in each habitat (Usher and Keiller, 1998).

c) Diversity index

Shannon-Weaver diversity index

$$H = -\sum_{i=1}^{S_T} p_i * \ln p_i$$

Where: p_i = proportion of individuals of i species

S_T = total number of species recorded

This index was used for total species and for specialist species counts. The latter index was used to analyse a diversity of unique species recorded/occurring only once in each vegetation type, termed here specialist species, to identify sites with conservation priority.

d) Dominance index:

Berger-Parker dominance index

$$d = \frac{N_{max}}{N_T}$$

Where: N_{max} = maximum number of individuals (of certain species) in the habitat

N_T = total individuals recorded in the habitat

These coefficients have been widely used in ecological and conservation studies (Swengel, 1998). Their power lies in their ability to create sufficient contrast between the different habitats compared.

Species accumulation curves were plotted to analyse if this short, but relatively intensive sampling effort recorded all or a fraction of the local butterfly community (Sparrow et al., 1994; Kremen, 1992, Natuhara *et al.*, 1998)

A Chi-square test was used to test for differences in species richness of butterflies between forest and edge, and grassland and edge.

3. Results

3.1. Vegetation description

Surveyed grasslands, Apiario G and Movene G, had more than 80% canopy cover below 0.5 m and less than 16% above 0.5 m in height (Figure 2). The vegetation in these sites consists of short grass and small, scattered shrubs. This habitat is home to species which special preference for open habitat. The forests, on the other hand (Mandimbe F and Mbilambi F), had a far greater occurrence of high canopy with 80% or more of the canopy comprising of trees with height greater than two meters. The forest edge sites (Mandimbe E, Mbilambi E and Movene E) consisted of a mixture of scattered tall trees and dominant medium-sized trees and shrubs (1-2m). This habitat may support a greater number of species than either forest or grassland due its transitional status.

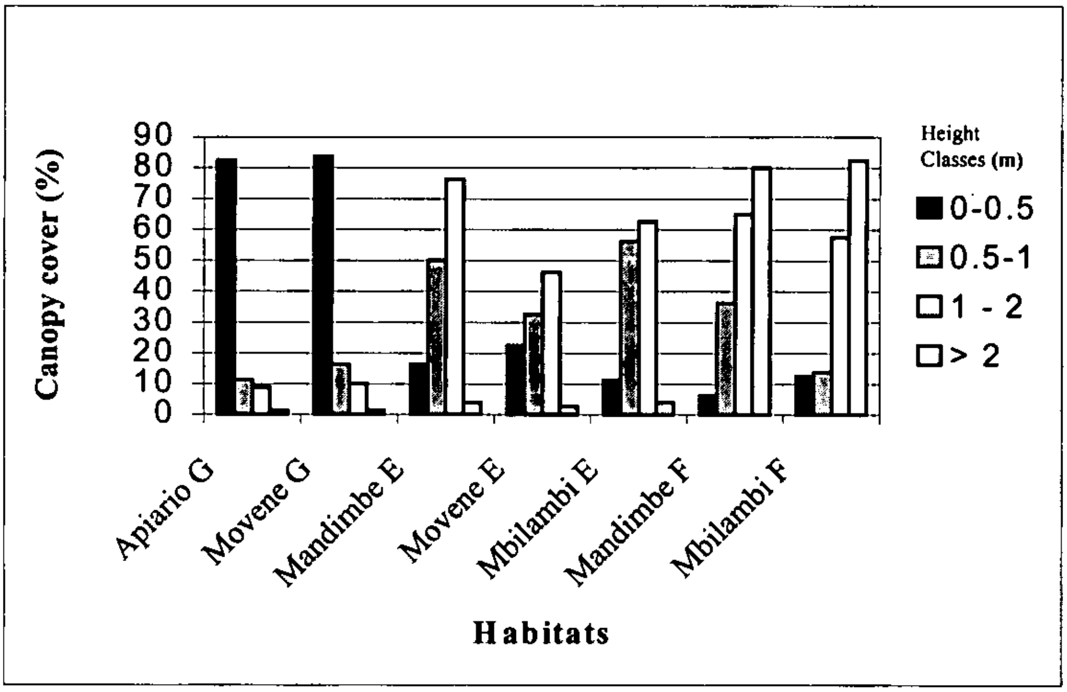


Figure 2. Canopy cover (%) in different height categories (m) on seven habitats sampled.

3.2. Butterfly species diversity

A total of 450 specimens representing 83 species were captured during the survey (Appendix 1). Mbilambi E had the highest number of individuals recorded (126), followed by Movene E and Mandimbe E with 68 and 69 individuals respectively (Table 1).

Charaxes candiope was the dominant species in the study area representing 10.7% of all individuals recorded in the overall survey, and 29% in Mandimbe F. *Bicyclus safitza safitza* and *Charaxes jasius saturnus* were the second most dominant, (7.8% of total sample) and 9.5 and 20.3% of individuals sampled in Mbilambi E and Mandimbe F respectively. *Stonehamina varanes varanes* represent 4.4% of all individuals and was most abundant in Mbilambi E, representing 7.1% of the total individuals recorded there.

In general the forest edge had the highest species diversity for both total and specialist species and more individuals than other habitat types. The forest edges, Mandimbe E, Mbilambi E and Movene E, had greatest total species which was reflected in high total species Shannon-Weaver diversity indices (3.16, 3.38 and 3.28 respectively) (Table 1). The grasslands, Apiario G and Movene G, placed second with 2.93 and 3.25 respectively. The forest core areas, Mandimbe F and Mbilambi F, had the lowest total species diversity, 2.36 and 2.72. The burned grassland, Apiario G, had a lower diversity index, 2.93, when compared with other unburned grassland, Movene G, 3.24.

The same trend was shown using Shannon-Weaver diversity index for specialist species. Forest edge had a greater diversity of specialist species than grassland and forest core area.

Table 1. Coefficient of similarity and Shannon-Weaver diversity index for total and specialist butterflies in Goba.

	Apia G	Move G	Mand E	Mbil E	Move E	Mand F	Mbil F	Total
Movene G	0.41							
Mandimbe E	0.15	0.21						
Mbilambi E	0.15	0.12	0.47					
Movene E	0.17	0.25	0.53	0.35				
Mandimbe F	0.04	0.04	0.48	0.45	0.50			
Mbilambi F	0.00	0.00	0.37	0.34	0.33	0.51		
Total Species	23	30	33	42	34	19	18	83
Unique Species	2	1	2	6	8	1	2	
Nº of individuals	39	54	69	126	68	59	35	450
Shannon-Weaver index (H) Total	2.93	3.25	3.16	3.38	3.28	2.38	2.72	
Shannon-Weaver index (H) specialists	1.95	1.98	2.19	2.25	2.25	0.00	0.64	
Berger-Parker index (d)	0.15	0.09	0.13	0.11	0.10	0.29	0.14	

Apia G = Apiario G (grassland)
Move G = Movene G
Mand E = Mandimbe E (edge)
Mbil E = Mbilambi E
Move E = Movene E
Mand F = Mandimbe F (forest)
Mbil F = Mbilambi F

3.3. Similarity indices

The matrix of pairwise coefficient of similarity (Table 1) showed high values (0.53 and 0.51) between two edges (Mandimbe E and Movene E), and the two forest habitats (Mandimbe F and Mbilambi F). That is an indication of high number of shared species between these habitats. Mbilambi E had a low association with other edges, indicating that this site has a distinct butterfly community. High Shannon-

Weaver diversity indices for total and specialist species in this site confirm this tendency.

The grasslands had a low similarity with other habitats, but the two were reasonable similar, $C_N = 0.41$. Grassland and forest had the lowest similarity coefficient (0 to 0.04) sharing only two species (which have been found in all sites, sampled), *Catopsilia florella* and *Charaxes castor flavifasciatus*.

3.4. Dominant species in each site

Hamanumida daedalus was the most abundant species in Apiario G, comprising 15% of total individuals (Table 2). *Charaxes candiope* was generally a dominant species in the study area, representing 29, 11 and 10% of all individuals recorded in Mandimbe F, Mbilambi E and Movene E respectively. *Bicyclus safitza safitza* was the most frequent species in Mandimbe E, comprising 13% of the all individuals sampled in this site. In Mbilambi F *Charaxes jasius saturnus* was the most dominant species, making up 14% of total individuals. *Catacroptera cloanthe cloanthe* was the most abundant in Movene G and represented 9% of the total record.

Table 2. Dominant species.

Species	Site	Dominance %
Hamanumida daedalus	Apiario G	15
Charaxes candiope	Mandimbe F	29
	Mbilambi E	11
	Movene E	10
Bicyclus safitza safitza	Mandimbe E	13
Charaxes jasius saturnus	Mbilambi F	14
Catacroptera cloanthe cloanthe	Movene G	9

Species accumulation curve shows that the sampling period was not long enough to record all species in the area (Figure 2). However, in the lower species richness habitats, forest and grassland, the majority of the butterflies species were recorded, which is reflected by the flattened graph's shape after 10 days of sampling effort. On the other hand, in forest edge the curve had not flattened off after 20 days, indicating that new species were still accumulating. That is an indication that further sampling effort was needed to cover true species richness.

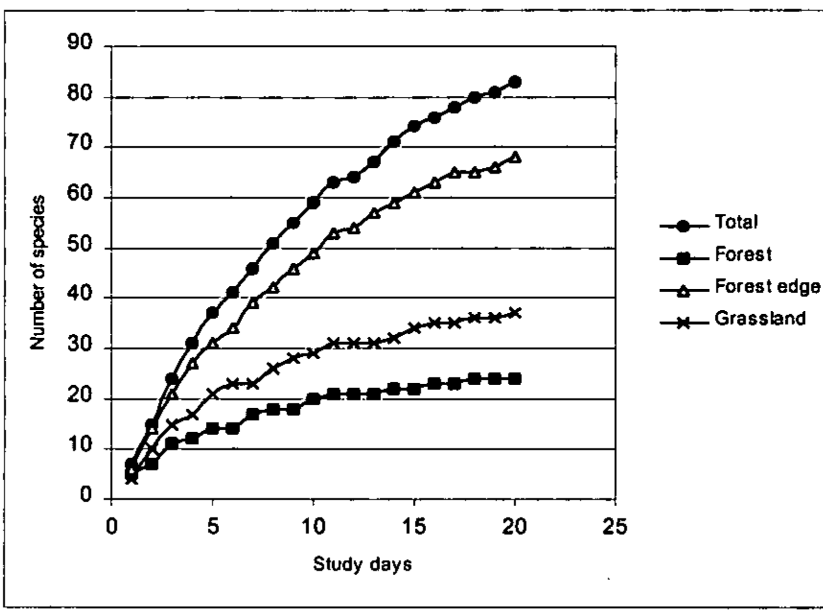


Figure 2. Lepidoptera species accumulation curve for all habits.

3.5. Edge vs. Core area comparisons

Forest edges had significantly more species than forest core areas in Mandimbe and Mbilambi (Table 3). Species counts for grassland, in Movene, and grassland edges with woodland were similar.

Table 3. Comparison between number of species recorded in core area of Mandimbe and Mbilambi forest and Movene grassland with their respective edges.

Site	Edge	Forest/ Grassland	χ^2	P
Mandimbe	33	19	3.77	0.10
Mbilambi	42	18	9.60	0.05
Movene	34	30	0.25	Ns

ns- not significant

Edge habitats had the greatest number of unique species (Figure 4) and not surprising the greatest number of shared species. Forest habitats showed low total and specialist species diversity (Table 1, Figure 4).

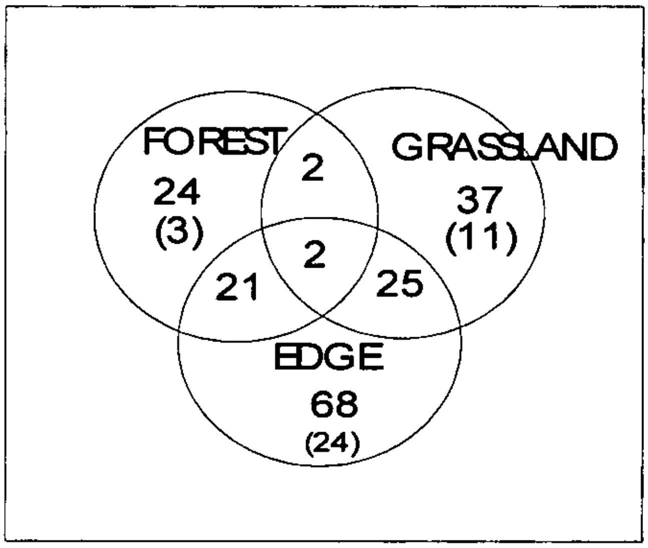


Figure 4. Total, shared and unique Lepidopteran species (in brackets) in forest, grassland and edge in the Goba area.

Grasslands share 25 species and forests 21 species with the edges. These results are an indication of existence of more tolerant species in grassland than core area of the forest. *Catopsilia florella* and *Charaxes castor flavifasciatus* are the only species appearing in all sites. The first one is well known for its migratory flight patterns; the latter, being a strong and rapid flier, could have been attracted to all habitats by the fruit traps.

4. Discussion

4.1. Species Diversity

Vegetation edges had a high total and specialist species diversity. These sites represent a natural form of disturbance, which promotes species richness for butterflies. Heterogeneity and rich mosaic of microhabitats with different light and abiotic conditions characterise these sites attracting secondary growth and sun-loving butterflies from both forest and surrounding matrix (Fleishman *et al*, 1999). Such sites are able to draw species from both forest and grassland vegetation types, but in addition were observed to have a number of unique species to them.

These results agree with Brown's findings (in Lovejoy *et al.*, 1986), where following a clearance of surrounding vegetation, forest butterfly species increased in Amazon forest edges. Apart from the attraction of young actively growing vegetation for the larvae, forest edges are often more attractive to butterflies than forest due increased sunlight penetration.

These results could be applied for a management of ecotourism and conservation planning and especially for those visitors interested in butterfly watching. For conservation purposes, a number of sites and types of habitat required to preserve all specialist species as well as the total number of species could be chosen. Forest edges are probably the best sites for butterfly ecotourism, as they are rich in butterfly species as well as being more accessible to people and less sensitive to disturbance.

There is no conflict between specialist and total species indices. Sites that ranked high for specialists were not poor in total butterfly species. This suggests that site prioritisation and management favouring the diversity and abundance of specialist butterflies would also favour the overall butterfly fauna possible in the same habitat. Many isolated forests in South Africa, such as Mariepskop in Mpumalanga, are known for isolated endemic species of butterflies, which act as flagship species for the "umbrella-type conservation (Henning and Henning, 1989).

The survey did not cover all seasons, so the analysis in this study should not be treated as absolute. The analyses are intended to be relative, to compare indices based on the catchable (abundant) or active individuals using methods presented and same data set assembled for similar surveys in all habitats (Spitzer *et al.*, 1997). Caution should be exercised in their interpretation. Fleishman *et al.* (1999) reported that annual variability in Walker River Basin, USA, was a more important influence of butterfly species diversity than habitat type.

Whether these results can be generalised for all seasons and for other areas has to be left for further investigations. Different sampling techniques could be used to explore the accuracy of this survey, this could include rearing of larvae. For example, total species accumulation curve suggest that more sampling effort was needed to cover up all species occurring in some edges. One of the limitations in the study is the use of fruit traps. For example, some well-known forest species or bushveld dwellers were recorded in grasslands, this could have been due to the effect of the attractiveness of the trap. However, for many genera like *Charaxes* this is the only practical method of sampling.

4.2. Conservation implications

For both specialist and total species counts, burning appears to be harmful to species diversity. Apiario G which had been burned two month before the survey, showed low species diversity compared with the other grassland site, Movene G. This undisturbed grassland site had higher species diversity than the forest edge site (Mandimbe E), and a lower density of individuals of the dominant species. So strong management strategies should be addressed to avoid or ban burning to favour not only butterfly species diversity, but that of other fauna and flora as well.

The low number of forest specialist butterfly species (3), *Protogoniomorpha parhassus aethiops*, *Belenois thysa thysa* and *Mylothris chloris agathina*, could be an indication of decreasing diversity. Forest species are most likely to become extinct with increasing habitat disruption. Past destruction of the forest could have lead to local extinction of endemic butterfly but because no baseline study was done or reported the actual trend is unknown. The conservation value of these species is becoming higher, regardless of the fact that both the number of species and diversity are relatively low.

Species identity, endemism or distinctness are more important for conservation prioritisation (Hill *et al.*, 1995). Species differ in their conservation value. Species with restricted distributions deserves the highest conservation priority because they are more vulnerable and prone to local or global extinction. Usually their habitats are restricted, so is not just species diversity, but mainly the presence of range-restricted species that needs consideration (Spitzer *et al.*, 1997). The forest at Goba might well be worthy of conservation protection, as continued sampling might reveal local endemic butterfly species (one *Charaxes* individual was not identifiable using available identification books).

The forests are home to a large number of *Charaxes* species many of which are both localised and listed in red data books (Henning and Henning, 1989). *Charaxes etesipe tavantensis* is the one of the recorded species that has an indeterminate conservation status. This species is endemic to southern Africa including the southern region of Mozambique. The species was recorded in Goba forest and the majority of its foodplants, *Azelia quanzensis*, lies in forest core area vegetation or natural occurring edges (Henning and Henning, 1989; DPAPPM/SPFFB, 1998).

Edges are not to be used as a substitute for grassland or forest if Goba endemic butterflies are to be conserved (Thomas, 1991). If forest or grasslands continue to be degraded or transformed for agriculture, local diversity in the edge might continue to increase but at the expense of regional diversity. Continued deforestation is likely to result in permanent loss of endemic forest butterflies and biodiversity for the region.

In order to conserve the three species of forest-specialist butterflies, some unmodified forest should be preserved. This strategy can help to conserve other taxa (snakes, monkeys, baboons and small mammals, were seen frequently during the survey). Usually forest specialists have low geographic ranges due human activities (Thomas, 1991). The forest edge species are mostly more opportunistic butterflies with wider geographic distribution than the closed canopy species (Spitzer *et al.*, 1997). Generalists are thus more likely to survive in modified habitats.

Most of the species found in the forest can be found in the edge, but are not generalists, which survive well on human modified habitat. They may visit forest edges for courtship, feeding or to make territories, but their foodplants, from the family of Acanthaceae, Capparidacea and Loranthaceae, are true forest species (Kroon, 1999; Werger, 1978; Low and Rebelo, 1996). Edge specialists live in natural successional habitat and so are able to occupy human modified areas that provide the same successional conditions. However, if the intensity of degradation or fragmentation increased they may not find the habitat acceptable.

In conclusion forest edges had greater species diversity and are important sites for butterfly conservation. However is important to maintain undisturbed forest for conservation of rare species, with low geographic range or being very sensitive to human activities (Wood and Gillman, 1997).

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Appendix 1. Butterfy census

Species	Total	Grassland		Forest edge			Forest	
		Apiario G	Movene G	Mandimbe E	Mbilambi E	Movene E	Mandimbe F	Mbilambi F
Fam. Nymphalidae								
Subfam. Danainae								
Amauris niavius dominicanus	3	-	-	-	3	-	-	-
Amauris ochlea ochlea	2	-	-	1	1	-	-	-
Danaus chrysippus (form liboria)	3	-	-	1	-	-	1	1
Fam. Nymphalidae								
Subfam.Satyrinae								
Bicyclus safitza safitza	35	-	-	9	12	5	5	4
Henotesia perspicua	9	-	-	2	2	2	2	1
Melanitis leda helena	10	1	-	1	8	-	-	-
Fam. Nymphalidae								
Subfam. Acraeinae								
Acraea aglaonice	1	-		1	-	-	-	-
Acraea anemosa	3	-	2	-	1	-	-	-
Acraea axina	5	-	1	1	2	1	-	-
Acraea eponina eponina	4	2	-	1	1	-	-	-
Acraea natalica natalica	3	-	1	-	-	2	-	-
Acraea oncaea	8	1	2	2	-	3	-	-
Acraea violarum	6	-	-	2	-	4	-	-
Fam. Nymphalidae								
Subfam. Charaxinae								
Charaxes achaemenes achaemenes	6	1	1	-	3	1	-	-
Charaxes brutus natalensis	10	-	-	-	4	-	3	3
Charaxes candiope	48	-	-	8	14	7	17	2
Charaxes castor flavifasciatus	10	1	1	2	3	1	2	-
Charaxes cithaeron cithaeron	6	-	-	1	2	1	1	1
Charaxes etesipe tavatensis	2	-	-	-	-	1	1	-
Charaxes ethalion	1	1	-	-	-	-	-	-
Charaxes jalhusa jalhusa	1	-	1	-	-	-	-	-

Appendix 1. (*Continued*)

Species	Total	Grassland		Forest edge			Forest	
		Apiario G	Movene G	Mandimbe E	Mbilambi E	Movene E	Mandimbe F	Mbilambi F
Fam. Nymphalidae								
Subfam. Charaxinae								
Charaxes jasius saturnus	35	-	-	7	5	6	12	5
Charaxes spp (not identified)	1	-	-	-	-	1	-	-
Charaxes zoolina zoolina	12	-	-	5	1	2	2	2
Stonehamina varanes varanes	20	-	-	1	9	5	4	1
Fam. Nymphalidae								
Subfam. Nymphalinae								
Byblia avantara acheloia	2	-	1	-	-	1	-	-
Byblia ilithyia	2	-	1	-	1	-	-	-
Catacroptera cloanthe cloanthe	7	-	5	1	1	-	-	-
Eurytela dryope angulata	5	-	-	-	5	-	-	-
Eurytela hiarbas angustata	1	1	-	-	-	-	-	-
Hamanumida daedalus	10	6	1	-	1	2	-	-
Fam. Nymphalidae								
Subfam. Nymphalinae								
Hypolimnas anthedon wahlbergi	1	-	-	-	-	1	-	-
Junonia hierta cebrene	7	3	4	-	-	-	-	-
Junonia natalica natalica	4	1	2	-	1	-	-	-
Junonia oenone oenone	3	2	1	-	-	-	-	-
Junonia orithya madagascariensis	4	1	3	-	-	-	-	-
Junonia terea elgiva	5	4	-	-	1	-	-	-
Neptis goochii	1	-	-	-	1	-	-	-
Neptis saclava marpessa	4	-	-	-	4	-	-	-
Protogoniomorpha parhassus aethiops	4	-	-	-	-	-	-	4
Fam. Lycaenidae								
Alaena amazoula ochroma	3	-	2	1	-	-	-	-
Aloides spp	1	-	1	-	-	-	-	-
Anthene butleri livida	2	-	-	-	-	2	-	-
Azanus jesous jesous	4	1	3	-	-	-	-	-

Appendix 1. (*Continued*)

		Grassland		Forest edge			Forest	
Species	**Total**	**Apiario G**	**Movene G**	**Mandimbe E**	**Mbilambi E**	**Movene E**	**Mandimbe F**	**Mbilambi F**
Fam. Lycaenidae								
Cyclyrius pirithous	7	2	4	-	-	1	-	-
Deudorix caerulea obscurata	2	-	-	2	-	-	-	-
Eicochrysops messapus mahallakoaena	2	-	1	1	-	-	-	-
Lampides boeticus	4	1	3	-	-	-	-	-
Lepidochrysops patricia	1	-	-	-	-	1	-	-
Lepidochrysops tantalus	1	-	-	-	-	1	-	-
Iolaus caeculus	2	-	-	-	-	1	1	
Iolaus pallene	1	-	1	-	-	-	-	-
Spindasis natalensis	1	-	1	-	-	-	-	-
Zizula hylax hylax	5	1	2	2	-	-	-	-
Fam. Pieridae								
Appias ephaphia orbona	1	-	-	-	-	1	-	-
Belenois creone severina	7	-	-	3	3	1	-	-
Belenois thysa thysa	2	-	-	-	-	-	-	2
Belenois zochalia	6	2	-	-	3	1	-	-
Catopsilia florella	8	1	1	2		3	1	-
Colotis antevippe gavisa	8	1	2	1	1	3	-	-
Colotis eucharis auxo	6	-	-	3	3	-	-	-
Colotis euippe omphale	5	-	2	1	-	2	-	-
Colotis evagore antigone	1	-	-	-	-	1	-	-
Dixeia pigea	3	-	-	-	3	-	-	-
Eronia cleodora cleodora	2	-	-	1	1	-	-	-
Eurema brigitta	4	3	1	-	-	-	-	-
Eurema desjardinsii marshalli	2	1	-	-	1	-	-	-
Eurema hecabe solifera	7	1	2	1	3	-	-	-
Leptosia alcesta inalcesta	6	-	-	1	4	-	-	1
Mylothris chloris agathina	1	-	-	-	-	-	1	-
Pinacopteryx eriphia eriphia	1	-	-	1	-	-	-	-

Appendix 1. (*Continued*)

Species	Total	Grassland		Forest edge			Forest	
		Apiario G	Movene G	Mandimbe E	Mbilambi E	Movene E	Mandimbe F	Mbilambi F
Fam. Papilolionidae								
Graphium colonna	3	-	-	-	1	-	1	1
Graphium morania	1	-	-	-	1	-	-	-
Graphium parthaon	3	-	-	1	2	-	-	-
Papilio dardanus	2	-	-	-	1	-	-	1
Princeps constantius constatius	10	-	-	-	6	1	1	2
Princeps demodocus demodocus	2	-	-	1	-	1	-	-
Princeps nireus lyaeus	5	-	-	-	2	-	1	2
Fam. Hesperiidae								
Coeliades pisistratus	1	-	-	-	-	1	-	-
Moltena fiara	1	-	1	-	-	-	-	-
Tagiades flesus	2	-	-	-	1	-	-	1
Diurnal Moths: Fam. Noctuidae								
Subfam. Chloephorinae								
Egybolis vaillantina	3	-	-	-	1	-	2	-
Fam. Arctiidae								
Subfam. Arctiinae								
Nyctemera leuconoe	6	-	-	1	3	-	1	1