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The butterflies of Ngazidja and their main habitats significances

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Abstract

Ngazidja, the biggest island of Comoros, is characterized by the higher level of endemism that is threatened by the rapid habitat degradation. This study was carried out to investigate the butterfly fauna of the forests of the Karthala (North and North-eastern slopes) and La Grille (Eastern slopes) in order to help the biodiversity conservation and protection. Transect counts were carried out to assess the endemicity, abundance and species richness of four zones of studies from 500m elevation. Natural forest, regenerated forest, plantation and grasslands were covered. 48 species in 5 families were observed and the distribution demonstrated to be influenced by the sites' elevation and the vegetation. The remains slots of natural forest at higher altitude shelters had higher abundance of endemicity but lower specific richness in contrast to plantation habitat that housing the biggest number of endemic species with lower abundance. Relatively common and migratory butterflies were mainly abundant in the open areas, where human activities intended to increase the variety of plants. The long term survival of this fauna and vegetation depends on one another. We argue that it is proper time to set long-time plans to conserve and protect areas of Comoro islands into action, with conservation strategies taking account the global endemicity and richness in all habitats.

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Introduction

It is estimated that around 20,000 species of butterflies are widespread, very obvious, easily recognizable and probably are best known taxonomically and ecologically (Shields, 1989; Thomas, 2005). They are highly sensitive to environmental changes because of their specialized ecology and coarse-grained perception of habitats. This component has made them extremely valuable indicators of ecosystem response as well as the state of habitats for biodiversity conservation (Bhardwaj *et al*., 2012; Kwon *et al*., 2013; Todisco *et al*., 2010; Van Swaay *et al*., 2012; Van Swaay *et al*., 2013). They belong to many groups of herbivorous coevolving with plants by feeding on them and pollinating them (Ehrlich and Raven, 1964).Butterflies are also good indicators to measure the intensity of predation in the field (Ota *et al*., 2014) and their colors provide them important eco-touristic value (Louette *et al*., 2004). However, like many others pollinators, they are facing serious decline due to habitat disturbance (Vu, 2013).

Different butterfly species respond differently to environmental factors, such as canopy cover, and butterfly communities of different habitats, have distinct ecological traits like host plant specificity and habitat specialization. Monophagous species tend to avoid human installation areas while cosmopolitan or polyphagous species may adapt in human modified areas (Koh and Sodhi, 2004). Butterfly larvae mostly feed on plants of one family, or a few chemically similar families chosen by adult females(Ehrlich and Raven, 1964). Thus, conservation planning should not be limited in the traditional ways which focus on "natural" ecosystems to protect from human, but also must consider areas where reconciliatory measure can be applied (Daily, 2003; Kendle and Forbes, 1997). Therefore, some basic knowledge of their ecology is necessary for effective conservation.

Bibliographic data on families Rhopalocera of Comoros exist now, particularly the butterfly of Ngazidja. Hesperidae, Papilionidae, Pieridae, Liceanidae and Nimphalidae occur in Comoros (BERNARDI, 1996; Lewis *et al*., 1998; Marsh *et al*., 2010). Some species and subspecies are strictly endemic of Ngazidja including *Graphium levassori* Oberthur, *Mylothris ngaziya* Oberthur, *Amauris comorana* Oberthur*Amauris ochlea affinis* Boisduval, *Papiliodardanus humblotii* Oberthur, *Papilio aristophontes* Oberthur, *Neptis cormiloti* Turlin, *Henotesia Comorana* Oberthur, *Charaxes paradoxa* Lathy, *Acrea comor* Pierre, *Charaxes castor commoranus* Rothschild (BERNARDI, 1996; ECDD *et al*., 2014; Lewis *et al*., 1998). There is no any endemic species in the family of Lyceanidae.However *Tagiades insularis grandis* Evans,*Borbo fatuellus dolens* Mabile, *Eagris sabadius comorana* Evans, and *Coelidae ramanatek comorana* are endemic subspecies of Comoros belonging to the family of Hesperiidae.

Ngazidja shares Comorian endemic species with her three sisters islands, among them *Acrea ranavolana* Boisd. (Nga, Moh., Nzu., Mao.), *Acreadammii* Volenh. (Nga., Moh., Ndz., Mao.), *Eurema floricola* Butler (Nga., Mwa., Ndz., Mao), *Belenois creona* Vollenhoven (Nga., Mwa., Ndz., Mao), *Belenois creona elisa* (Nga., Mwa., Ndz., Mao), *Acrea massaris jodina* (Nga, Mwa ., Nzu.) (BERNARDI, 1996; Lewis *et al*., 1998). *Amauris comorana*, *Amauris nossima*,*Graphium levassori*, *Papilio aristophontes* are listed as threatened and are fully protected (Collins and Morris, 1985; MPE, 2001; Union-des-Comores, 2009, 2014). This Island shares endemic and migratory butterfly species with the three Comorian islands, Madagascar and many afrotropical countries (Bernardi, 1996; ECDD *et al*., 2014).

For conservation issues; Comoros have ratified international legislations such as the Convention of Biodiversity (U-N, 1992) and adopted National plans and policy including the National Environmental Policy (RFIC, 1994), and the Environmental Action Plan (1994). However, there is no palpable terrestrial protected area in the four islands. In Ngazidja the deforestation is proceeding rapidly up the slopes of

Mount Karthala, which maintains the most important forest on the all four islands. In addition this fauna is still exposed to the threat of the Karthala volcano that erupts at least one time per ten years (Union-des-Comores, 2008).

The motivation to conduct this study rises from the lack of information in the last decades. In addition, the current project on terrestrial protected areas needs updated data that reflects the most reality in the field. The last study focused on butterflies of Ngazidja was conducted by Lewis *et al.* 1998. Despites the valuable data on richness and abundance of Nymphalidae, Papilionidae and Pieridae, data on the families Lyceanidae and Hesperidae are lacking. In addition, as described above, the anthropogenic pressure such as clearingfor extension agricultural, timber trade have increased this last decades. The frequency of Karthala volcano activity is still growing causing damages on flora and fauna. For example, in 2005 the ash erupted from Karthala covered almost the whole island particularly the vegetation of crops, meadows and forests (DGSC, 2012). The high mortality due to this dramatic habitat degradation may change the composition of butterflies that are very sensitive to environmental change.

Updated information on the current state and distribution of the Ngazidja butterflies may be needed for harmonizing conservation procedures. Endemicity, distribution and species richness are mainly important in the context of biodiversity conservation. Such data should be constantly updated due to rapid habitat changes. Here we investigated the richness and abundance of the butterfly of Ngazidja islands in the « La Grille » (Eastern slopes) and of the Karthala (North and North-eastern slopes) and their main ecological significances.

Materials and methods

Study area

Ngazidja (Fig. 1) is the largest and the most western of the four islands forming Comorian archipelago: Ngazidja (Nga), Mwali (Mwa), Ndzuani (Ndz) and Maore (Mao). It is located in the Mozambique Channel between East Africa and Madagascar (11°20'S and 43°11'E). It has a total area of 1148 km² and the 2/3 of the island from the center to the south is dominated by the Karthala, an active volcano that peaks at 2361m (Chambrin *et al.*, 2013). The north part of the island is occupied by La Grille, another massive shield of 1187m whose forest is severely depleted (Viette, 1980; Youssouf, 2012). Two main seasons, hot-wet (November-May) and cool-dry (June-October) are separated by short transition periods characterized by continuous evolution of temperature and humidity. The mean temperature vary between 26° to 28°C during the hot-wet season and 25° to 27°C during the cool-dry season. The annual temperature varies between 25°C and 28° C respectively in low and high altitude and may rise to 35°C or decrease to 0°C (on the top of Karthala). Rainfall on the dry north-eastern coast is 1900mm and exceeds 4000mm per year at the Karthala forest (Battistini and Verin, 1984; Chambrin *et al.*, 2013; François, 1987).

Fig. 1. Zones of study: Tsinimoipanga, Iidjikundzi, Hantsongoma and La Grille.

Dense rainforest, savanna, mangrove, ticket of *Phillipia comorensis*, grassland, plantations and cultivated fieldsare the common Habitat of Karthala (Adjanohun *et al*., 1982; Andiliyat, 2007). The rainforest covers the altitude above 600 to 1200m of Karthala. This ecosystem undergoes anthropogenic pressure including under plantation collection of firewood, timber extraction and clearance. (Adjanohun *et al*., 1982; Andiliyat, 2007; Louette and Stevens, 1992).

The forest degradation is carried out primarily by the people of the villages bordering the zone. The latest investigations by the Project Team "OCB / MDGs" 2008 revealed man's intervention at 1172m at Idjikoundzi (Region of Dimani) and at 1238 m at Tsinimoichongo (Region of Mbadjini) while the highest peak of the island is 2361m (Union des Comores, 2009). Another important threat is the Karthala volcano which erupted every ten years before 2005 and almost every year after 2005 (Union-des-Comores, 2008). Natural vegetation and crops along with animals are burnt during the passage of the lava flow (Adjanohun *et al*., 1982). Despite the lack of scientific assessments about the loss of fauna and flora caused by these catastrophes, the death of many animals and plants are evident during volcano eruptions.

Data collection

We surveyed butterflies at three areas located in the North-eastern slopes of Karthala (forest of Tsiniwapanga, Idjikunzi and Hantsongoma) and at one area in the eastern slopes of La Grille forest (Fig. 1). Four main types of habitats were identified in these areas: primary forest, secondary forest, plantation, grasslands. Surveys were conducted between 8th Marchand 8th July 2012. Butterflies were surveyed using transect methodology adapted from (Lewis *et al*., 1998) and (Marsh *et al*., 2010), which were previously used for surveying butterflies respectively in Ngazidja and Ndzuani. Two observers walked in constant pace and recorded all butterflies seen in an imaginary box of 5m long x 5m wide x 5m high in front of the first observer. The first observer identified individual butterflies during flight using binocular if necessary. The second observer recorded the butterfly name, time, geographic coordinates and altitude using GPS. A total of 134 transects, each of 5 minute (200m length) were carried out between 500m and 2361m elevation corresponding to the top of Karthala. Surveys were carried between 9.00 a.m. and 4 p.m. when butterflies are usually active. In our analyses, we did not consider transect routes passing through two types of habitat.

Species from the families of Papilionidae and Nymphalidae could be easily identified in the flight. Capture was necessary for reliable identification of individuals of Lycaenidae and Hesperiidae, and for the specie belonging to genus *Eurema*. Voucher specimens were collected for individuals that could not be identified in the field, for later identification at the laboratory of Comoros University. Individuals that were neither identified in the field nor caught were noted and excluded from the sample (0.76% of total sample).

Data analysis

To compare the richness of endemic butterfly species between the four habitat types and between the four surveyed zones, ANOVA followed by Tukey's post hoctest was performed using SPSS statistic v.20; the graph was built using Sigma Plots 10.

Variation in butterfly community composition among altitude categories (500-700m, 700-900m, 900-1100m, >1100m) was tested for significance using ANOSIM (ANalysis Of SIMilarities) based on a Bray-Curtis similarity matrix (Bray and Curtis 1957) with the software PRIMER ® version 6 (Clarke and Gorley 2001). ANOSIM is analogous to standard univariate ANOVA and tests the variance within and between a priori defined groups in ordinate space. The R_{ANOSIM} statistic values are absolute measures of how separated the a priori defined groups are. A zero (0) indicates that there is no difference among groups, whereas a one (1) indicates that all samples (sites) within groups are more similar to one another than any samples from different groups (Clarke and Gorley 2001). The results of the ANOSIM are presented in addition to a multidimensional scaling (MDS) ordination based on the same similarity matrix. Finally, SIMPER analysis (percentage of similarity) was conducted to to investigate the relative contribution of individual butterfly species to dissimilarity among habitat types and sampling zones.

Results

A total 1174 individuals of butterflies of 48 species (3 endemic species, 12 endemic subspecies and 33 non endemic species) belonging to the families Hesperidae, Papilionidae, Pieridae, Nimphalidae and Lycaenidae were recorded in 134 transects. (A complete list of species is reported in Appendix 1). In the representation of the results we treated endemic species and subspecies as "endemic". The total number of species ranged from 31 to 41 considering the zones of survey and varied from 6 to 45 in the habitat types (Table 1).

Table 1. Species observation in the zones of studies.

Studied zones	Total number of species	Endemic species	Habitat type	Total number of species	Endemic species
La Grille	31	10	Natural forest	6	6
Hantsongoma	41	16	Regenerated forest	35	10
Idjikunzi	41	12	Plantation	45	15
Tsinimoipanga	38	11	Grassland	36	9

Community composition and specific richness by altitude

Considering the 4 altitude categories the multidimensional (MDS) scaling (Fig 2 A.) revealed a gradual separation following the increase in elevation. The community of >1100m have high dissimilarity from others, mainly explained by the lower number of species recorded at those altitudes (Fig 2B.). Also differences in species composition contributed to differentiate the communities at different altitudes (Table 2). The ANOSIM analysis showed that all the pair wise comparisons were significant and the percentage similarity follows the tendency described in the MDS diagram. The lowest levels of similarities between were found between butterfly communities colonizing the lowest (500-700m) and highest (>1100m) altitudes (11.18%; ANOSIM: R=0.570; P=0.001) and between the communities sampled at 700-900 m and >1100 m (14.95%; ANOSIM: R=0.599; P=0.1). On the contrary, the most similar butterfly communities appeared to be those surveyed from 700 m: we found 25.84% of similarity between 700-900 and 900-1100 m (ANOSIM: R=0.134; P=0.028), and 27.26% between 900-1100 m and >1100 m (ANOSIM: R=0.212; P=0.026).

Endemic butterflies and habitat types

The percentages of endemism were 100%, 75.25%, 35.25% and 34% in natural forest, regenerated forest, plantations and grassland, respectively. We compared the endemic richness per transect between the four habitats using ANOVA followed by Tukey's post hoc test. Endemic butterflies were recorded in 14, 21, 21, and 23 respectively in Natural forest, Regenerated forest, Plantation, and Grassland. The results revealed no difference between the mean number of endemic individual butterflies found in natural and regenerated forest (P>0.05) and between transects of plantation and grassland habitats (P>0.05). However, natural forest and regenerated forest were highly rich in endemic individual butterflies than plantations and grassland communities (P < 0.05) (Fig. 3).

Table 2. SIMPER analysis – Butterfly species that contributes to the similarity between communities according to the ranges of altitudes.

Groups 500-700 m
Mean similarity: 23,63

Species	Mean abundance	Mean similarity	Contribution%	Cumulated contribution (%)
Eurema brigitta pulchella	0,77	3,9	16,5	16,5
Eurema floricola anjuana	0,74	3,42	14,46	30,96
Eurytela dryope	0,94	2,4	10,16	41,11
Catopsilia florella	0,82	1,92	8,13	49,25
Danaus chrysippus	0,92	1,87	7,92	57,17
Mylothris ngazya	*0,47*	*1,54*	*6,51*	*63,68*
Phalanta phalantha	0,61	1,49	6,3	69,98
Byblia anvatara	0,57	1,19	5,06	75,03
Euchrysops osiris	0,51	1,15	4,86	79,89

Group 700-900 m
Mean similarity : 27,03

Species	Mean abundance	Mean similarity	Contribution%	Cumulated contribution (%)
Mylothris ngazya	1,88	9,36	34,62	34,62
Eurema floricola anjuana	1,31	6,6	24,43	59,06
Eurema brigitta pulchella	0,81	2,98	11,01	70,06
Hypolimnas misippus	0,48	0,94	3,47	73,53
Eurytela dryope	0,31	0,87	3,22	76,75
Euchrysops osiris	0,41	0,82	3,04	79,79

Group 900-1100 m
Mean similarity: 30,59

Species	Mean abundance	Mean similarity	Contribution%	Cumulated contribution (%)
Mylothris ngazya	2,24	15,97	52,2	52,2
Heteropsis comorensis	0,63	3,53	11,52	63,72
Papilio aristophontes	0,46	2,57	8,4	72,12
Eurema brigitta pulchella	0,48	1,5	4,91	77,03
Heteropsis comorana	0,35	1,12	3,65	80,69

Group >1100
Mean similarity : 50,89

Species	Mean abundance	Mean similarity	Contribution%	Cumulated contribution (%)
Heteropsis comorensis	2,22	20,52	40,33	40,33
Heteropsis comorana	1,92	20,12	39,54	79,86

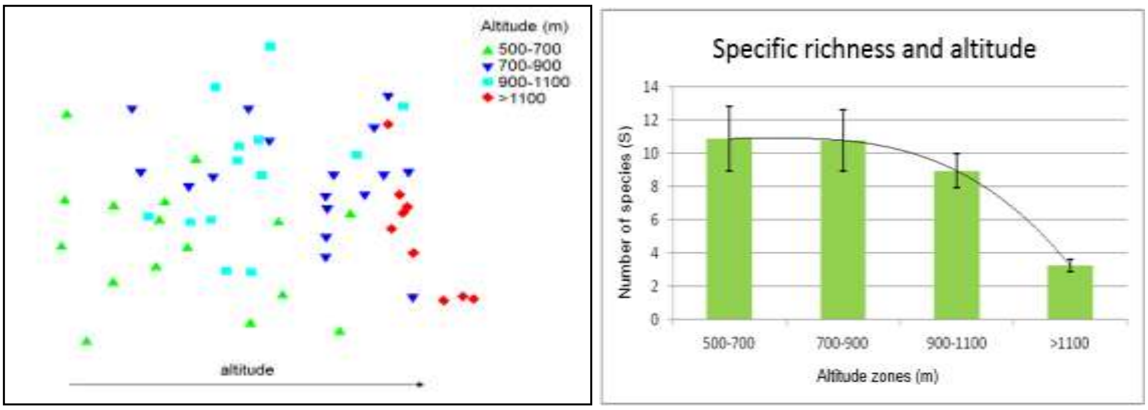

Fig. 2. A) MDS (Multidimensional scaling) of mean similarities of Bray-Curtis in the altitude, B) Specific richness and altitude.

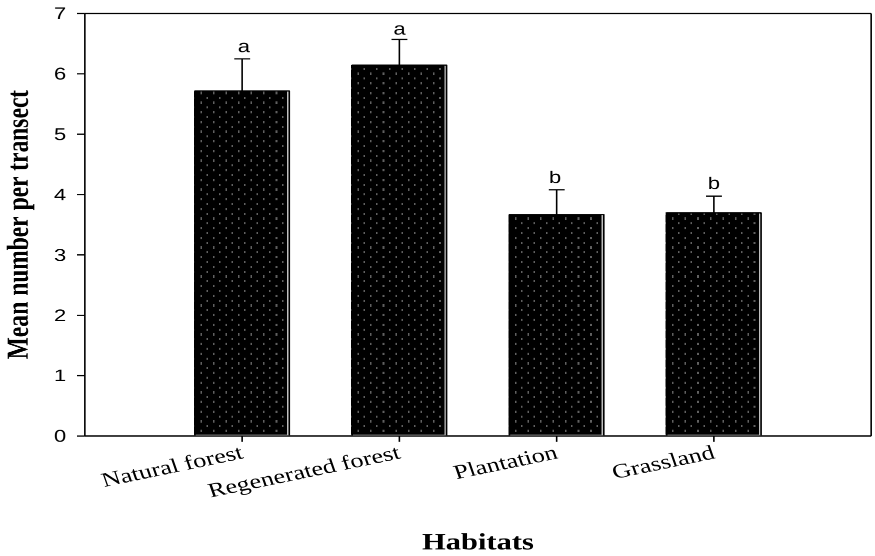

Fig. 3. Butterfly Endemic individual richness in the four habitats. Differing letters denote significant differences ($P<0.05$).

The number of endemic species ranged from 6 to 14 from natural forest to plantations. Plantation had a great number of endemic species, but lower relative abundance whereas natural forest that had only six endemic species, exhibited higher mean relative abundance compared to other habitats. Among the 15 endemic species recorded *Mylothris ngaziya, Papilio aristophontes, Henotesia comorana and H. comoresis salami and Papilio dardanus humbloti* were found in the four habitat types. *Belenois creona elisa*, *Tagiades insularis grandii*, *Acraea masaris jodina* wererecorded only for the plantation habitat (Table 3).

Table 3. Relative abundance of endemic butterflies.

Endemic species	Habitat types			
	Plantation (42)	Grassland (35)	Regenerated forest (42)	Natural forest (15)
Henotesia comorana	0.25	0.04	0.79	0.50
Henotesia comorensis salimi	0.32	0.04	0.91	1.50
Mylothris ngaziya	1.08	0.75	2.12	0.75
Papilio aristophontes	0.05	0.17	0.35	0.67
Papilio dardanus humbloti	0.13	0.04	0.44	0.33
Baoris fatuelis dollens	0.06	0.13	0.09	0.50
Eurma floricola	0.62	1.21	0.38	
Coelidae ramanatek comorana	0.06		0.06	
Amaoris ochlea affinis	0.06	0.04		
Neptis cormiloti	0.10		0.41	
Eagris sabadius comorana	0.02	0.04		
Belenois creona elisa	0.03			
Papilio epiphorbas predica	0.02			
Tagiades insularis grandii	0.00			
Acraea masaris jodina	0.30			
Total	2.79	5.56	2.46	4.18
Means	0.21	0.27	0.62	0.74

Note: Values represent the mean number of individual of the species per transect. The numbers in bracket are the number of transects. The empty rows means the species was not observed in that habitat.

Comparison of butterfly communities between zones

In the 4 studied zones, the number of total and endemic species ranged from 31 to 41 and 10 to 16 respectively. The total number of individual butterflies recorded varied from 152 to 409 while and the percentage of individual endemic butterflies varied between 15,77% and 25,66%. The number of species did not vary significantly between the three zones of Karthala: 38were sampled at Tsinimoipanga, 41 at Hantsongoma and 41 at Idjikunzi. However, the highest number of individuals was recorded in the forest of Tsinimoipanga (409 individuals) (Table 4). The mean number of individual butterflies per transect seemed to increase from the forest of La Grille (4.89), Hantsongoma (6.78), Idjikunzi (9.6) to Tsinimoipanga (11.32) (Table 4), but we did not observed any statistical significant difference between the four zones P>0.05. However, the comparison between butterfly communities revealed relatively lower similarity between zones on the basis of butterfly communities and significantly different separation: 20.87% of similarity between butterfly communities at Tsinimoipanga and Hantsongoma (ANOSIM: R=0.193; P=0.030), 17.48% between Idjikundzi and La Grille (ANOSIM: R=0,172; P=0.018), 20.33% between Hantsongoma and La Grille (ANOSIM: R=0.132; P=0.034).

Table 4. Specific richness in the four zones.

Zones of study	Species		Individuals		
	Total	Percentage endemic	Total	Percentage endemic	Mean numbers per transect
La Grille	31	32,26%	152	20,39%	4.89
Hantsongoma	41	39,02%	265	25,66%	6.78
Idjikunzi	41	29,27%	355	15,77%	9.6
Tsinimoipanga	38	28,95%	409	20,05%	11.32

Table 5. Summary of the observations in the four habitats.

Observation	Natural forest	Regenerated forest	Plantation	Grassland
Total individuals	31	291	624	221
Total endemic individual	31	213	224	60
Percentage of endemic individual (%)	100	75.25	35.25	34
Total endemic relative abundance	4.18	5.56	2.79	2.46
Mean endemic relative abundance (per transect)	0.74	0.62	0.21	0.27

Discussion

Endemic butterflies and habitats

Respectively in natural and secondary forest 6 and 9 species represent 100% and 75.25% of endemic individual in these habitats (Table 1&5). The situation was different in man settlement or modified habitats (plantations and grasslands) where respectively in plantation and grassland 15 and 9 species represent only 35.25% and 34% of total species richness. This is in line with previous studies in Ngazidja and Ndzuani that stated endemic species to be more adapted to forest habitat (disturbed and non-disturbed forest) than to non-forest habitat (Lewis *et al.*, 1998; Marsh *et al.*, 2010). This fact was explained by a significant difference of the total relative abundances which were 4.18 and 5.56 in natural and regenerated forest against 2.79 and 2.46 in plantations and grasslands. Increasing landscape complexity had a positive effect on butterfly species richness, but not on butterfly abundance (Jonason *et al.*, 2011). We also found the same result by comparing the richness of endemic species (mean number per transect) in the four habitat types. The number of endemic species recorded in the plantation was higher than in all the other habitats (Table 3).

Community composition, species richness and altitude

The multidimensional scaling ordination plot confirmed that dissimilarity between butterfly communities increased with elevation. The butterfly communities of 700-900 and 900-1000 were more similar while the community of the higher altitude (>1100m) shared very little similarity with the other butterfly communities. Although the number of species forming the communities may play major role in this repartition, it is clear that it was due to the number of species as well as the identity of species that compose communities.

Butterfly and zones of study area

There was no statistical difference in number of butterfly species and individuals ($P>0.05$). The number of butterflies recorded at Tsinimoipanga and Idjikunzi is similar, and slightly higher than the two other zones. These two zones (Tsinimoipanga and Idjikunzi) shelter the greatest part of the patches of natural forest in Ngazidja Island. The remaining parts are modified by human activities and dominated by plantations and agro forestry. This variety of habitats may offer to butterflies suitable conditions for their development. Hantsongoma seems to have a high percentage of endemism compared to the other areas. The main characteristic of this zone is the presence of the ''Lake Hantsongoma'' which is located at 1050m of altitude. This lake is surrounded by a huge number of plant species dominated by guava trees. Further studies should be conducted to confirm the hypothesis that this lake and the sourrounding areas represent an optimal habitatfor most butterfly species. The zone of Hantsongoma supports a great vegetation variability like vegetable (Potatos, carrot …), fruit trees (Litchi tree, orange tree…) and other plantations such as banana. Most of the butterflies recorded in this zone were not forest species. La Grille area, whose forest has almost entirely disappeared, has the fewest number of butterfly species (31) among the four zones, and is located at the lowest elevation (1084m). The most parts of this zone are open areas dominated by cultivated fields and grasslands. The remaining parts are dominated by introduced trees (*Eucalyptus spp*, *Psidium cattleyanium*, *Lantana camara*.), endemic plants (*Tambourissa leptophylla*, *Weinnmania comorensis*), other plantations of bananas and cassavas. In brief the vegetation is very ordinary and does not attract the butterfly fauna.

Conservation approach

In congruence with some previous studies (Daily, 2003; Miller and Hobbs, 2002), we suggest to rethink to the traditional method of butterfly conservation which focuses more on conserving primary forests for the native endemic species. Conserving the intact forest will contribute to the conservation of species on which their life depend (Lewis *et al*., 1998), but would insufficient to preserve butterfly communities in the non-forest habitats. Our study reveals that the ratio of endemic species is higher in forest habitat, but non-forest habitats such plantations support more than two times the number of endemic species recorded in natural forest. In addition all the 15 endemic species recorded in this study occurred in non-forest, primarily plantation habitat. Instead of preserving the primary forest habitats from human activities, the conservation planning should focus on reconciliatory measure between man and ecosystem, in order to take into account endemicity in non-forest habitat.

Conservation is not only aimed at protecting endangered species. One of the key question for conservation planning is 'how to support many species at lower cost?' (Myers *et al*., 2000). Probably because of the variety of plants and the reduction of the canopy, man modified areas tend to attract many butterfly species including endemic ones. Non-endemic butterflies are always considered as non-high value of conservation as they can be found elsewhere (Lewis *et al*., 1998), but they may play key role in the persistence of heterogeneous communities (Zavaleta *et al*., 2001). One possible conservation action in the non-forest habitat would be to revegetate the habitat with native butterfly host plants.

In Ngazidja the conservation is highly delicate because of the Karthala volcano. To prevent the persistent erosion of fauna, an alternative or supplementary conservation plan focusing on La Grille forest may be viable (although this zone supports few species compared to others zones). The situation is highly critical considering that the remaining forest patches of Ngazidja island covers only this mountain and it has lostthe 64% since 1971 (DEF, 2009). The principal cause is due to forest clearing for agriculture and timber trade in addition to the destruction caused by the lava flow during volcanic eruptions. Furthermore, the creation of urban or lowland protected gardens may represent an additional conservation strategy to preserve Ngazidja butterfly diversity.

Conclusion

All butterflies recorded in natural and forests were native species and they were also observed in the three other habitat. The plantation habitat shelters a higher number of endemic species than natural end regenerated forest, with very lower relative abundance. However, we did not record any non-native species in the natural forest. It is clear that the least disturbed habitats represent very suitable environment for the development of some endemic species but man-modified habitats actually support all the butterfly species recorded in this study suggesting that butterfly conservation at Ngazidja and the other islands of Comoros should not only focus on natural forest, but should take in consideration the parameters that attract butterfly species in other habitats.

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Appendix 1. Butterfly species recorded in this study.

Families	Species	Observation			
		Endemic species	**Endemic sub-species**	**Non endemic**	**Number butterfly observed**
HESPERIDAE	*Baoris fatuellus dolens*		*Comoros*		13
	Borbo gemella			X	10
	Coelides forestan forestan			X	5
	Coelides ramanatek Comorana		*Comoros*		9
	Eagris sabadius comorana		*Comoros*		3
	Pelopidas mathias			X	1
	Tagiades insularis grandis		*Comoros*		4
LYCEANIDAE	*Cacyreus darius*			X	4
	Euchrysops osiris			X	42
	Freyeria trochylus			X	4
	Lampides boeticus			X	10
	Leptotes pirithous			X	2
	Zizeeria knysna			X	12
	Zizina antanossa			X	20
	Zizula hylax			X	24
NYMPHALIDAE	*Acraea eponina*			X	30
	Acraea lia			X	26
	Acraea masaris jodina		*Ngazidja*		13
	Acraea neobule			X	6
	Acraea ranavalona			X	11
	Amauris ochlea affinis		*Ngazidja*		6
	Bicyclus anynana			X	23
	Byblia anvatara			X	27
	Danaus chrysippus			X	44
	Eurytela dryope			X	44
	Henotesia comorana		*Comoros*		56
	Henotesia comorensis salimi		*Comoros*		79
	Hypolimnas anthedon drucey				4
	Hypolimnas misippus			X	26
	Junonia oenone oenone			X	13
	Junonia radhama			X	16
	Melanitis leda helena			X	6
	Neptis cormilloti	*Ngazidja*			18
	Phalanta phalanta			X	29
	Vanesa Cardui			X	1
PAPILIONIDAE	*Graphium angolanum*			X	5
	Papilio Aristophontes			X	36
	Papilio dardanus humbloti		*Comoros*		30
	Papilio demodecus			X	19
	Papilio epiphorbas praedicta		*Ngazidja*		4
PIERIDAE	*Appias epaphia*			X	9
	Appias Sabina			x	3
	Belenois creona elisa		*Comoros.*		2
	Catopsilia florella			X	47
	Eurema brigitta			X	74
	Eurema floricola anjouana		*Comoros.*		89
	Eurema regularis			X	23
	Mylothris ngaziya	*Ngazidja*		x	192
Total observation		3	12	**33**	1174

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