Butterfly distribution and habitat conservation status at A Rocha Dakatcha Nature Reserve, Kilifi County, Kenya

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ABSTRACT

Diverse human pressures are degrading coastal forests with profound implications on invertebrate biodiversity. Butterfly species are key ecosystem indicators and their distribution may become a campaign tool towards conservation of specific habitats. However, a baseline survey of Dakatcha butterflies is long overdue, necessitating this study at A Rocha Dakatcha Nature Reserve (ARDNR) in Kilifi County. The objective was to identify Dakatcha butterfly species, their distribution, threats to the forest and conservation measures by the community in 2019. The modified pollard walk method was used to collect butterfly species from 21 transects from which the Shannon index of diversity, Margalef's species richness index and evenness index were calculated. A total of 125 butterflies from five distinct vegetation types were captured and identified to represent 42 species and 25 genera from the documented 5 butterfly families in Kenya. Questionnaires were administered to twenty-nine community members on threats and conservation activities in ARDNR. The exercise confirmed that main threats to ARDNR butterfly habitat are agriculture, charcoal production from *Diospyros corni* and *Dobera glabra* and timber extraction from *Manilkara mochisia*, *Brachystegia spiciformis*, *Thespesia danis* and *Brachylaena huillensis* trees. The targeted deforestation of key tree species providing a suitable microclimate and an array of nectar sources to all threaten butterfly existence in the forest. Fortunately, there are five main stakeholders implementing diverse conservation projects including promotion of energy-saving *jikos* and beekeeping. In conclusion this study confirms existence of all five families of Kenyan butterflies in ARDNR. The presence of 13 butterfly species in the regenerating forest patch further

affirming the importance of practical all-inclusive forest management and that community awareness enhances diversification of livelihood activities alongside sustainable forest utilization.

Keywords: Butterfly diversity, abundance, protected areas, community groups, forest conservation.

INTRODUCTION

Dakatcha forest also referred as the Dakatcha woodland covers an area of 465,070 acres of land with 32% being forest and 17% is woodland (Birdlife, 2021). Dakatcha woodland is one of the last patches of the relatively intact coastal woodland that together with the Arabuko Sokoke F Forest (ASF) and the fragments of Madunguni forest form the only remaining part of the Northernmost block of Miombo woodland that used to extend from southern Somalia to Northern Mozambique (Musila et al. 2006). The woodland is recognized by Conservation International as a coastal forests global hotspot and a Key Biodiversity Area (KBA) (Mbuvi et al. 2011). Unfortunately, 50% of this important indigenous woodland has been degraded by agricultural expansion, unregulated logging, rampant charcoal burning and the expansion of commercial pineapple plantations (A Rocha, 2020). Such rapid and great loss has already given rise to a fragmented coastal forest forcing stakeholders to institute a holistic sustainable forest management plan to ensure a "win-win" scenario for the community and biodiversity (Nature Kenya, 2014).

To further counter the rapid degradation of this important ecosystem, the local community has established eight

Community Conserved Areas (CCAs) from 2014 and the government has gazetted six Kaya forests (Nature Kenya, 2014). Notably, a private reserve of 2100 acres by A Rocha Kenya is galvanizing restoration of the forest through their Dakatcha Nature Reserve (ARDNR) established in 2014. The primary objectives of the community-led initiative is to conserve the indigenous coastal forest and its threatened wildlife particularly endemic species such as sokoke scops owl (*Otus ireneae*), sokoke pipit (*Anthus sokokensis*), clark's weaver (*Ploceus golandi*) and the golden-rumped elephant-shrew (*Rhynchocyon chrysopygus*) (A Rocha, 2020). Such commendable actions necessitate regular updates of the local and regional biodiversity databases to a determine efficacy of small but connected *in-situ* conservation projects.

Butterflies are seen as good indicators of environmental changes mainly because of their specificity to vegetation type, rapid response to perturbation, taxonomic tractability and ease of sampling (Gowda et al, 2011). Hence, robust butterfly population and diversity affirms the health status of a given forest ecosystem (Manzoor & Sadat, 2013). Interestingly, Vu (2009) states that butterfly diversity is usually lower in natural forests, higher in disturbed forests and highest in moderately disturbed forests or forest edges. Unfortunately, this aspect has not been confirmed from the many studies on coastal forest because most of the studies focus on mammal, reptile and vascular plants populations due to their influence on the tourism sector. These haphazard studies leave gaps in invertebrate database especially butterfly species despite their importance for monitoring impacts of habitat degradation (Lindenmayer and Likens, 2009) and environmental change on biodiversity (Bonebrake et al. 2010). Though neighbouring Arabuko Sokoke Forest has had several butterfly surveys including those done by Ayiemba (1997) and Aden and Dharani (2019), Dakatcha still lacks a comprehensive butterfly database. Hence, this paper seeks to contribute to the coastal butterfly database as an urgent aspect considering that degradation of natural forest habitats is a conservation priority (Birdlife, 2021).

Accordingly, two entwined knowledge gaps such as lack of an up-to-date butterfly species database and the role of the community in reducing forest degradation informed this study in Dakatcha woodland in 2019. The objectives were to analyse butterfly diversity across the vegetation types in ARDNR, establish anthropogenic threats towards forest resources and delineate activities promoting sustainable forest utilization by the community within the Dakatcha woodland.

METHODOLOGY

Study area

Dakatcha woodland is an unprotected forest patch comprising of different vegetation types and seasonal wetlands and which lies between latitude $2^{\circ}52'05''\text{S}$ and longitude $39^{\circ}56'59''\text{E}$ in Kilifi County (Figure 1). This study was done at two sections within the woodland. First, the butterfly study was conducted at the A Rocha Kenya's Dakatcha Nature Reserve. Second, data on community threats and conservation activities were collected randomly from the households within the Dakatcha woodland area.

The mean annual rainfall of Dakatcha woodland is 500-900mm that is distributed in two rain seasons: long rains from March to June while short rains from October to December. The area's mean annual temperature is 24°C to 32°C where the mean maximum temperature is 28°C to 31°C and the minimum temperature is 20°C to 23°C (Nature Kenya, 2014).

Figure 1: A map of Dakatcha woodland (Source: Author)

The area is mainly inhabited by the Mijikenda, specifically the Giriama community with an estimated population of 191610 in 2019 (KNBS, 2019). The population is sparsely distributed with more people being concentrated in major trading centres such as Marafa, Garashi, Baricho and Adu. The people are mainly involved in small scale crop production and animal husbandry. Recent interest in pineapple farming has increased logging and charcoal burning to create land for the pineapple farms (A Rocha, 2020 & Nature Kenya, 2014).

Study Design

Butterfly distribution study

Intensive sampling of butterflies was carried out in June and December 2019. Butterflies were studied using the modified pollard walk method (Pollard, 1977) which involved modified belt transects of approximately 20 square meters wide and 1km long. Transects were located along paths and small roads in all the vegetation types of the woodland. Butterflies were captured between 7am - 6pm using a butterfly net when either in flight or when settled and secured by a rapid sweep of the net. Thereafter, the butterfly net was held upside down and the captured butterfly samples collected carefully after stunning the butterfly by pinching their thorax.

Three pictures of both the lower and the upper parts of the captured butterfly wings were taken from each specimen. This was carefully done by folding the butterfly wings backward to avoid losing the colourful scales from the wings that aid in identification. The pictures were then uploaded to the virtual museum of FitzPatrick Institute of Ornithology for identification purposes. Additional data recorded included the date, time, locality of capture, coordinates of the area and the collector's name. Specimens were then mounted, labelled and preserved in the Lepidoptera collection at National Museums of Kenya.

Threats and community participation in conservation of ARDNR

Questionnaires were administered to 29 persons identified using random sampling to identify threats to the forest habitat and the conservation activities in the ARDNR area. The focus was on to find out source of conservation knowledge, participation level and the conservation activities in the Dakatcha community. In addition, activities going on in the woodland were recorded and pictures taken for further inquiry from the community.

Data Interpretation and Analysis

Butterfly data were pooled for total diversity and calculated using the formulas below.

1. *Margalef's species richness* index was used to compare species richness across different habitats.

$$Dmg = \frac{s - 1}{\log N}$$

Where,
s is the number of species.
N is the sampling size.

2. *Shannon index of diversity* was used to calculate the diversity of butterfly species across habitat

$$H' = \frac{N \ln N - \sum (ni \ln ni)}{N}$$

Where,
N is the total number of observed species.
ni is the number of individuals in species i.

3. *The evenness index* was used to calculate whether species are distributed evenly across different habitats.

$$E_D = \frac{H'}{\ln N}$$

Where,
H is the Shannon Index
ln is proportion of maximum value of individuals.

RESULTS AND DISCUSSION

Butterfly Diversity

A total of 42 species of butterfly were recorded belonging to 25 genera and the key five families including *Papilionidae*, *Pieridae*, *Nymphalidae*, *Lycaenidae* and *Hesperiidae*. ARDNR hosts family *Hesperiidae* consisted of one genus and one species (0.8%), *Papilionidae* represented by two genera and four species (4.80%), *Lycaenidae* with two genera and three species (5.0%), *Nymphalidae* with 11 genera and 15 species (36%) and *Pieridae* with nine genera and 19 species (52.80%) (Figure 2).

Figure 2: Family-wise dominance of butterfly species from ARDNR habitat

The total captured species represent about 14% of butterfly species recorded at the nearby Arabuko Sokoke Forest which is 45 times larger than ARDNR and hosts about 301 butterfly species (Ayiemba, 1997). A recent study conducted by Aden & Dharani (2019) in Arabuko Sokoke Forest Nature Reserve recorded 106 species from 49 Genera of five families *Papilionidae*, *Pieridae*, *Nymphalidae*, *Lycaenidae* and *Hesperiidae*.

Notably, the rainy season over the December holiday could also be a reason for few members of family *Hesperiidae* (Figure 2) being recorded as some might have migrated to a drier areas or rain might have an influence on their breeding behaviour. Ayiemba (1997) indicated that this

genus could have more representation in coastal forests.

Butterflies from the family *Papilionidae* were sighted to move at fast rates and settles on flowers on tall trees thus only a few individuals were captured. Moreover, sweep nets could be biased towards the larger butterflies that are more easily identified either in flight or in traps.

In terms of evenness index the main five vegetation types had a medium diversity i.e., $1.5 < X < 2.5$ except for the mixed forest that recorded a high diversity of 3.204 with the evenness E'' of 0.9421 (Table 1). The habitats indicated in table 1 were restricted to only those in which butterfly species were captured during the survey, therefore, this does not mean that their ranges were only confined to these habitats.

The results confirm the richness of ARDNR because it supports all five families *Papilionidae*, *Nymphalidae*, *Pieridae*, *Lycaenidae* and *Hesperiidae* that have ever been documented in Kenyan coastal forests by Larsen (1991), Ayiamba (1997) and Aden & Dharani (2019).

Butterfly habitat distribution

A total of 125 butterflies were captured in 21 transects from five distinct vegetation types of *Brachystegia*, *Cynometra*, mixed forest, recently cultivated land (mixed herbs) and grassland. The comprehensive list in Table 2 below will allow the readers to view online pictures and ecological details of captured butterfly species by clicking on the provided link from the virtual museum database.

The highest captured butterfly numbers were from the mixed forest and the mixed herbs (regenerating) habitats (Figure 3). The high numbers at the mixed forest seem to be supported by the open nature and the stratification of the vegetation which enables flowers with enough nectar sources and provides larval host plants for the larvae. Such habitat attracts both the specialist and generalist species and the savanna species as well, the latter being mostly the *Pieridae*. This finding is consistent with Habel et al. (2018) who stated that different habitats in each area contribute more to butterfly species diversity.

Table 1: Summary of the butterfly statistics at ARDNR

Site	Margalef richness index	Shannon Index	Evenness (E'')
<i>Brachystegia</i> forest	3.789	2.305	0.9611
<i>Cynometra</i> forest	3.04	2.025	0.974
Mixed forest	7.112	3.204	0.9421
Mixed herbs (recently cultivated)	3.432	2.399	0.9352
Tall grass	1.82	1.427	0.8867

Figure 3: Distribution of butterfly families in Dakatcha woodland

Table 2: A comprehensive list of captured butterfly species in ARDNR

No.	Family	species name	Vegetation zonation	VMLink
1	HESPERIIDAE	<i>Spialia sp</i>	Mixed forest	http://vmus.adu.org.za/?vm=LepiMAP-689377
2		<i>Hypolycaena pachalica</i>	Mixed forest	http://vmus.adu.org.za/?vm=LepiMAP-689578
3		<i>Hypolycaena pachalica</i>	Mixed forest	http://vmus.adu.org.za/?vm=LepiMAP-689582
4		<i>Leptotes sp</i>	<i>Cynometra webberi</i>	http://vmus.adu.org.za/?vm=LepiMAP-689595
5	LYCAENIDAE	<i>Hypolycaena philippus philippus</i>	Mixed forest	http://vmus.adu.org.za/?vm=LepiMAP-689798
6		<i>Hypolycaena pachalica</i>	<i>Brachystegia spiciformis</i>	http://vmus.adu.org.za/?vm=LepiMAP-690374
7		<i>Leptotes sp</i>	Mixed forest	http://vmus.adu.org.za/?vm=LepiMAP-701099
8		<i>Leptotes sp</i>	<i>Cynometra webberi</i>	http://vmus.adu.org.za/?vm=LepiMAP-701109
9	NYMPHALIDAE	<i>Hamanumida daedalus</i>	Mixed forest	http://vmus.adu.org.za/?vm=LepiMAP-689379
10		<i>Acraea anemosa</i>		http://vmus.adu.org.za/?vm=LepiMAP-689381
11		<i>Danaus chrysippus dorippus</i>		http://vmus.adu.org.za/?vm=LepiMAP-689382
12		<i>Acraea anemosa</i>		http://vmus.adu.org.za/?vm=LepiMAP-689383
13		<i>Acraea anemosa</i>		http://vmus.adu.org.za/?vm=LepiMAP-689388
14		<i>Byblia anvatara acheloia</i>		http://vmus.adu.org.za/?vm=LepiMAP-689575
15		<i>Junonia natalica natalica</i>		http://vmus.adu.org.za/?vm=LepiMAP-689583
16		<i>Acraea neobule neobule</i>		http://vmus.adu.org.za/?vm=LepiMAP-689589
17		<i>Ypthima sp</i>		http://vmus.adu.org.za/?vm=LepiMAP-689598
18		<i>Byblia ilithyia</i>		http://vmus.adu.org.za/?vm=LepiMAP-689600
19		<i>Byblia anvatara acheloia</i>		http://vmus.adu.org.za/?vm=LepiMAP-689603
20		<i>Byblia anvatara acheloia</i>		http://vmus.adu.org.za/?vm=LepiMAP-689604
21		<i>Danaus chrysippus dorippus</i>	Mixed herbs (recently cultivated)	http://vmus.adu.org.za/?vm=LepiMAP-689799
22		<i>Danaus chrysippus dorippus</i>		http://vmus.adu.org.za/?vm=LepiMAP-689800
23		<i>Acraea neobule neobule</i>		http://vmus.adu.org.za/?vm=LepiMAP-689801
24		<i>Phalanta phalantha aethiopica</i>		http://vmus.adu.org.za/?vm=LepiMAP-689808
25		<i>Acraea neobule neobule</i>		http://vmus.adu.org.za/?vm=LepiMAP-689809
26		<i>Junonia oenone oenone</i>		http://vmus.adu.org.za/?vm=LepiMAP-689863
27		<i>Junonia oenone oenone</i>		http://vmus.adu.org.za/?vm=LepiMAP-689864
28		<i>Danaus chrysippus dorippus</i>		http://vmus.adu.org.za/?vm=LepiMAP-689869
29		<i>Acraea neobule neobule</i>		http://vmus.adu.org.za/?vm=LepiMAP-689870
30		<i>Hypolimnas misippus</i>		http://vmus.adu.org.za/?vm=LepiMAP-689871
31		<i>Acraea neobule neobule</i>		http://vmus.adu.org.za/?vm=LepiMAP-689873
32		<i>Hypolimnas misippus</i>		http://vmus.adu.org.za/?vm=LepiMAP-689882
33		<i>Junonia hierta cebrene</i>		http://vmus.adu.org.za/?vm=LepiMAP-689884
34		<i>Phalanta phalantha aethiopica</i>	<i>Manilkara shrubs</i>	http://vmus.adu.org.za/?vm=LepiMAP-689885
35		<i>Acraea anemosa</i>	<i>Manilkara shrubs</i>	http://vmus.adu.org.za/?vm=LepiMAP-689967
36		<i>Hypolimnas misippus</i>	<i>Manilkara shrubs</i>	http://vmus.adu.org.za/?vm=LepiMAP-689969
37		<i>Byblia anvatara acheloia</i>	<i>Dobera glabra</i>	http://vmus.adu.org.za/?vm=LepiMAP-689973
38		<i>Junonia natalica natalica</i>	Mixed forest	http://vmus.adu.org.za/?vm=LepiMAP-690376
39		<i>Byblia ilithyia</i>	Tall grass	http://vmus.adu.org.za/?vm=LepiMAP-701086
40		<i>Byblia ilithyia</i>	Tall grass	http://vmus.adu.org.za/?vm=LepiMAP-701087
41		<i>Byblia ilithyia</i>	Tall grass	http://vmus.adu.org.za/?vm=LepiMAP-701090
42		<i>Junonia natalica natalica</i>	Tall grass	http://vmus.adu.org.za/?vm=LepiMAP-701091
43		<i>Junonia natalica natalica</i>	Tall grass	http://vmus.adu.org.za/?vm=LepiMAP-701092
44		<i>Byblia ilithyia</i>	Tall grass	http://vmus.adu.org.za/?vm=LepiMAP-701094
45		<i>Byblia anvatara acheloia</i>	Mixed forest	http://vmus.adu.org.za/?vm=LepiMAP-701096
46		<i>Byblia ilithyia</i>	Mixed forest	http://vmus.adu.org.za/?vm=LepiMAP-701098
47		<i>Byblia ilithyia</i>	Mixed forest	http://vmus.adu.org.za/?vm=LepiMAP-701100
48		<i>Eurytela dryope angulata</i>	<i>Cynometra webberi</i>	http://vmus.adu.org.za/?vm=LepiMAP-701103
49		<i>Byblia anvatara acheloia</i>	<i>Cynometra webberi</i>	http://vmus.adu.org.za/?vm=LepiMAP-701104
50		<i>Telchinia serena</i>	<i>Brachystegia spiciformis</i>	http://vmus.adu.org.za/?vm=LepiMAP-701187
51		<i>Byblia ilithyia</i>	<i>Brachystegia spiciformis</i>	http://vmus.adu.org.za/?vm=LepiMAP-701188
52		<i>Byblia anvatara acheloia</i>	<i>Brachystegia spiciformis</i>	http://vmus.adu.org.za/?vm=LepiMAP-701189
53		<i>Melanitis leda</i>	<i>Brachystegia spiciformis</i>	http://vmus.adu.org.za/?vm=LepiMAP-701195

54	PAPILIONIDAE	<i>Papilio demodocus demodocus</i>	Mixed herbs (recently cultivated)	http://vmus.adu.org.za/?vm=LepiMAP-689875
55		<i>Graphium philonoe philonoe</i>	Manilkara shrubs	http://vmus.adu.org.za/?vm=LepiMAP-689968
56		<i>Papilio demodocus demodocus</i>	Manilkara shrubs	http://vmus.adu.org.za/?vm=LepiMAP-689970
57		<i>Graphium philonoe philonoe</i>	Manilkara shrubs	http://vmus.adu.org.za/?vm=LepiMAP-689971
58		<i>Graphium colonna</i>	<i>Brachystegia spiciformis</i>	http://vmus.adu.org.za/?vm=LepiMAP-690373
59		<i>Papilio constantinus constantinus</i>	<i>Brachystegia spiciformis</i>	http://vmus.adu.org.za/?vm=LepiMAP-701192
60	PIERIDAE	<i>Colotis evagore antigone</i>	Mixed forest	http://vmus.adu.org.za/?vm=LepiMAP-689378
61		<i>Colotis calais calais</i>	Mixed forest	http://vmus.adu.org.za/?vm=LepiMAP-689389
62		<i>Dixeia doxo costata</i>	Mixed forest	http://vmus.adu.org.za/?vm=LepiMAP-689390
63		<i>Belenois gidica abyssinica</i>	Mixed forest	http://vmus.adu.org.za/?vm=LepiMAP-689574
64		<i>Nepheronia buquetii buquetii</i>	Mixed forest	http://vmus.adu.org.za/?vm=LepiMAP-689576
65		<i>Nepheronia buquetii buquetii</i>	Mixed forest	http://vmus.adu.org.za/?vm=LepiMAP-689577
66		<i>Colotis euipe omphale</i>	Mixed forest	http://vmus.adu.org.za/?vm=LepiMAP-689579
67		<i>Colotis evagore antigone</i>	Mixed forest	http://vmus.adu.org.za/?vm=LepiMAP-689581
68		<i>Colotis protomedia</i>	Mixed forest	http://vmus.adu.org.za/?vm=LepiMAP-689584
69		<i>Nepheronia buquetii buquetii</i>	Mixed forest	http://vmus.adu.org.za/?vm=LepiMAP-689585
70		<i>Nepheronia buquetii buquetii</i>	Mixed forest	http://vmus.adu.org.za/?vm=LepiMAP-689586
71		<i>Colotis protomedia</i>	Mixed forest	http://vmus.adu.org.za/?vm=LepiMAP-689587
72		<i>Nepheronia buquetii buquetii</i>	Mixed forest	http://vmus.adu.org.za/?vm=LepiMAP-689588
73		<i>Teracolus eris eris</i>	Mixed forest	http://vmus.adu.org.za/?vm=LepiMAP-689590
74		<i>Eurema brigitta brigitta</i>	Mixed forest	http://vmus.adu.org.za/?vm=LepiMAP-689591
75		<i>Teracolus eris eris</i>	<i>Cynometra webberi</i>	http://vmus.adu.org.za/?vm=LepiMAP-689592
76		<i>Colotis protomedia</i>	<i>Cynometra webberi</i>	http://vmus.adu.org.za/?vm=LepiMAP-689593
77		<i>Colotis ione</i>	<i>Cynometra webberi</i>	http://vmus.adu.org.za/?vm=LepiMAP-689594
78		<i>Eronia dilatata</i>	Mixed forest	http://vmus.adu.org.za/?vm=LepiMAP-689596
79		<i>Colotis ione</i>	Mixed forest	http://vmus.adu.org.za/?vm=LepiMAP-689597
80		<i>Dixeia doxo costata</i>	Mixed forest	http://vmus.adu.org.za/?vm=LepiMAP-689599
81		<i>Dixeia doxo costata</i>	Mixed forest	http://vmus.adu.org.za/?vm=LepiMAP-689601
82		<i>Colotis calais calais</i>	Mixed forest	http://vmus.adu.org.za/?vm=LepiMAP-689602
83		<i>Colotis protomedia</i>		http://vmus.adu.org.za/?vm=LepiMAP-689802
84		<i>Catopsilia florella</i>		http://vmus.adu.org.za/?vm=LepiMAP-689803
85		<i>Catopsilia florella</i>		http://vmus.adu.org.za/?vm=LepiMAP-689806
86		<i>Colotis ione</i>		http://vmus.adu.org.za/?vm=LepiMAP-689807
87		<i>Catopsilia florella</i>		http://vmus.adu.org.za/?vm=LepiMAP-689810
88		<i>Teracolus eris eris</i>		http://vmus.adu.org.za/?vm=LepiMAP-689811
89		<i>Catopsilia florella</i>		http://vmus.adu.org.za/?vm=LepiMAP-689865
90		<i>Pinacopteryx eriphia eriphia</i>		http://vmus.adu.org.za/?vm=LepiMAP-689866
91		<i>Teracolus eris eris</i>		http://vmus.adu.org.za/?vm=LepiMAP-689867
92		<i>Colotis evagore antigone</i>	Mixed herbs (recently cultivated)	http://vmus.adu.org.za/?vm=LepiMAP-689868
93		<i>Colotis protomedia</i>		http://vmus.adu.org.za/?vm=LepiMAP-689872
94		<i>Colotis protomedia</i>		http://vmus.adu.org.za/?vm=LepiMAP-689874
95		<i>Colotis evagore antigone</i>		http://vmus.adu.org.za/?vm=LepiMAP-689876
96		<i>Catopsilia florella</i>		http://vmus.adu.org.za/?vm=LepiMAP-689877
97		<i>Colotis ione</i>		http://vmus.adu.org.za/?vm=LepiMAP-689878
98		<i>Catopsilia florella</i>		http://vmus.adu.org.za/?vm=LepiMAP-689879
99		<i>Colotis protomedia</i>		http://vmus.adu.org.za/?vm=LepiMAP-689880
100		<i>Teracolus eris eris</i>		http://vmus.adu.org.za/?vm=LepiMAP-689881
101		<i>Teracolus eris eris</i>		http://vmus.adu.org.za/?vm=LepiMAP-689883
102		<i>Eronia dilatata</i>	<i>Dobera glabra</i>	http://vmus.adu.org.za/?vm=LepiMAP-689972
103		<i>Colotis ione</i>	<i>Dobera glabra</i>	http://vmus.adu.org.za/?vm=LepiMAP-689974
104		<i>Eronia dilatata</i>	<i>Dobera glabra</i>	http://vmus.adu.org.za/?vm=LepiMAP-689975
105		<i>Dixeia doxo parva</i>	<i>Dobera glabra</i>	http://vmus.adu.org.za/?vm=LepiMAP-690366
106		<i>Eronia dilatata</i>	<i>Dobera glabra</i>	http://vmus.adu.org.za/?vm=LepiMAP-690370
107		<i>Colotis ione</i>	<i>Dobera glabra</i>	http://vmus.adu.org.za/?vm=LepiMAP-690372
108		<i>Eurema brigitta brigitta</i>	<i>Brachystegia spiciformis</i>	http://vmus.adu.org.za/?vm=LepiMAP-690375
109		<i>Dixeia doxo costata</i>	Mixed forest	http://vmus.adu.org.za/?vm=LepiMAP-690377
110		<i>Eronia dilatata</i>	Mixed forest	http://vmus.adu.org.za/?vm=LepiMAP-690378
111		<i>Colotis euipe omphale</i>	Mixed forest	http://vmus.adu.org.za/?vm=LepiMAP-690379
112		<i>Eurema hecabe solifera</i>	Tall grass	http://vmus.adu.org.za/?vm=LepiMAP-701088
113		<i>Colotis protomedia</i>	Tall grass	http://vmus.adu.org.za/?vm=LepiMAP-701089
114		<i>Colotis danae eupompe</i>	Tall grass	http://vmus.adu.org.za/?vm=LepiMAP-701093
115		<i>Colotis evenina sipylus</i>	Mixed forest	http://vmus.adu.org.za/?vm=LepiMAP-701095
116		<i>Belenois creona severina</i>	Mixed forest	http://vmus.adu.org.za/?vm=LepiMAP-701097
117		<i>Belenois aurota</i>	<i>Cynometra webberi</i>	http://vmus.adu.org.za/?vm=LepiMAP-701102
118		<i>Colotis protomedia</i>	<i>Cynometra webberi</i>	http://vmus.adu.org.za/?vm=LepiMAP-701110
119		<i>Colotis danae eupompe</i>	<i>Cynometra webberi</i>	http://vmus.adu.org.za/?vm=LepiMAP-701185
120		<i>Colotis euipe omphale</i>	<i>Brachystegia spiciformis</i>	http://vmus.adu.org.za/?vm=LepiMAP-701190
121		<i>Eronia dilatata</i>	<i>Brachystegia spiciformis</i>	http://vmus.adu.org.za/?vm=LepiMAP-701191
122		<i>Eronia dilatata</i>	<i>Brachystegia spiciformis</i>	http://vmus.adu.org.za/?vm=LepiMAP-701193
123		<i>Eronia dilatata</i>	<i>Brachystegia spiciformis</i>	http://vmus.adu.org.za/?vm=LepiMAP-701194
124		<i>Dixeia doxo costata</i>	<i>Brachystegia spiciformis</i>	http://vmus.adu.org.za/?vm=LepiMAP-701196
125		<i>Dixeia doxo costata</i>	<i>Brachystegia spiciformis</i>	http://vmus.adu.org.za/?vm=LepiMAP-701197

In addition, regeneration in the cultivated land supports a high diversity of herb plants with flowers that provide assorted nectar sources for butterflies. This was confirmed by the 13 butterfly species observed in the mixed herbs area affirming the gradual success of conservation activities in the regenerating habitat. Thereby, the results conform to the study done by Vu (2009) showing that butterfly diversity is usually lower in natural forests, higher in disturbed forests, and highest in moderately disturbed forests or forest. Drawing on this understanding, forest managers can encourage the community to adopt the “Shamba System” or the Plantation Establishment and Livelihood Improvement Scheme (PELIS). PELIS which effectively supports biodiversity, livelihoods and forest regeneration (Agevi et al., 2016).

Threats to butterfly habitat

This objective was covered through detailed survey of the habitat in ARDNR and respondent feedback in the community. Deforestation was through charcoal burning (23%) mainly targeting *Diospyros cornii* (mkulu) and *Dobera glabra* (mkami), illegal harvesting of poles (12%), timber and carving wood (23%) from *Manilkara mochisia* (Mnago), *Brachystegia spiciformis* (Mrihi), *Thespesia danis* (Muhowe) and *Brachylaena huillensis* (muhuhu) trees (Figure 4). Clearing of the understory for agriculture (35%) especially pineapple plantations is responsible for the gradual reduction of *Cynometra* forests (mfunda). Fuelwood extraction (8%) is the least threat to the butterfly habitat maybe due to the surveillance in the nature reserve.

The habitat threats can be perceived in two main ways. First, the targeted deforestation of key tree species that define a given specific forest habitat structure and these trees provide much needed canopy cover that encourages a conducive microclimate for butterflies. Second, the deliberate clearing of the forest understory herbs and shrubs for agriculture which then reduces available nectar sources for the butterflies.

Community conservation efforts

Respondents identified the following benefits from

Dakatcha forest as being the main reason they would participate in its conservation; food (23%), employment (6%), animal protein (13%), honey (21%), medicinal plants (11%) and construction materials (25%). Interestingly, some respondents were aware of the ecological services the forest provides to them such as attraction of rain (62%) and soil erosion control (38%) indicating that the community appreciates their forest habitat.

In terms of active conservation there are five main stakeholders driving the conservation agenda at ARDNR. The conservation projects revolve around community education and awareness on the destructive practices of charcoal burning and replacing unsustainable agriculture practices with conservation-led activities. These stakeholders are:

- A Rocha Kenya community and environment education team working with local church organisations and schools.
- Farming God's Way (FGW) organisation that actively trains farmers in conservation agriculture implementation to conserve Dakatcha forest ecosystem.
- Nature Kenya and Birdlife organisations involved in conservation of the clark's weaver bird (*Ploceus golandi*) and other endemic species.
- Anglican church donating goat breeds as a source of milk and meat to the community and education on sustainable tomatoes farming.
- Women groups like the Amani and Upendo groups constitute about 58% of those interviewed and they participate in farming of chicken, goats, and fast growing cassava hybrid (Tajirika). The groups also purchase energy saving jikos for its members.

Most of the training given to the community highlights the ecological interactions that enable them to harvest honey, medicinal plants and wild fruits. Such practical education encourages the community to participate in simple farming practices that earn income like beekeeping (23%) and other options of clean energy (27%) at the household level.

Figure 4: Deforestation activities degrading the indigenous habitat of ARDNR

CONCLUSION

This study provides habitat specific baseline data of the butterflies in Dakatcha woodland. It has reaffirmed that the Dakatcha woodland harbours diverse species representing the five documented butterfly families in Kenya. This research has also shown that though butterflies are evenly distributed within four distinct habitats, they are in high numbers at the mixed forest habitat, a trend that conforms to other scientific studies. It also highlights threats to butterfly habitat through the deliberate illegal extraction of specific tree species and clearing of the understory for pineapple farming, which may impact butterfly distribution. On the positive side the study concludes by highlighting actions of key stakeholders to enhance awareness and increase participation towards sustainable utilization of the natural resources of the Dakatcha woodland. Such positive actions will no doubt increase availability of a large diversity of plants that enable existence of a diverse array of butterfly species that can attract tourists and researchers to the Dakatcha woodland and earn revenue for the community and Kilifi County. The study recommends further research on species abundance by analysing the correlation between species-habitat, species-vegetation and seasonal variation to guide implementation of proposed conservation strategies efficiently.

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