

Research Article

Investigation of the Distribution and Abundance of Butterfly in the Nature Reserve of Arabuko Sokoke Forest Reserve, Kilifi County, Kenya

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Abstract

Arabuko Sokoke Forest (ASF) is ranked second in Africa and fifty globally in biodiversity richness. It is the largest remnant of what was originally an extensive strip of dry coastal forest that extended from Southern Somalia in the horn of Africa to the Eastern Cape in the south. The forest consists of three vegetation types; the *Brachystegia*, *Cynometra* and Mixed forest and provide habitat cover to the many flora and fauna. Extraction of adult butterfly by the local adjacent population for export has been going on over 25 years. The ten (10) current research investigates the distribution and

abundance of butterfly's species along transects within the nature reserve in all three habitat types. Physical observation of butterflies using pollard walk 1500m standardized transects were used. The level of disturbance can interfere with habitat structures, species distribution and abundance. The seasonality can affects species distribution and resource partitioning. A potential seasonality difference in butterfly composition within the sites was tested and diversity indices were measured. A total of 106 species of 49 genera and 5 families were sighted. Shannon–Weiner diversity indices and evenness showed (H') 1.42, (E') 0.79

respectively. The overall butterfly abundance was very different in 2017 as compared to the 1997. The results show that there were no significant changes in rank abundance for the identified 60 set of species. The results show that butterflies are evenly distributed based on availability of host plants and nutrition for adult butterflies.

Keywords: Abundance; Lepidoptera; Arabuko Sokoke Forest; Distribution; Transects; Population

Introduction

Arabuko Sokoke Forest (ASF) is ranked second in Africa and fifty globally in biodiversity richness. It is 420 km² (Oyugi *et al.*, 2007). The Arabuko Sokoke forest is among the forested Kenya represents an excellent study region to test for potential effects from different environmental conditions and seasonal fluctuations of resource availability on the occurrence of species. The forest comprises of different natural forest types and portion of plantations. Arabuko Sokoke forest experiences strong climatic seasonality, with rainy and dry seasons (Oyugi *et al.*, 2007). Butterfly abundance and diversity is high during the rainy season, while it becomes scarce during the dry season.

Seasonal shifts (rainy and dry season) may strongly impact the availability of resources like food, and thus strongly affect the occurrence and distribution of taxa, and the behaviour, i.e. movement and migration of individuals. Thus, seasonality can impact species behaviour and the structure of a community (Hulbert and Haskell, 2003). Potential responses to habitat changes may be mediated by the degree of ecological specialization and dispersal behavior of taxa (Tscharntke *et al.*, 2002, 2012). Both parameters determine the ecological plasticity and adaptability of

species on environmental changes, including anthropogenic disturbances (Habel *et al.*, 2018). Habitat generalists use various resources and different habitats and thus are assumed to respond more plastic on environmental changes if compared with habitat specialists relying on very specific habitat conditions and resources (Louy *et al.*, 2007; Junker and Schmitt, 2010).

Some butterfly species display a high level of ecological specialization in regard of caterpillar host plant selection and habitat structures (Settele *et al.*, 1999; Habel *et al.*, 2018). The taxonomy, distribution and habitat of most Kenyan butterfly species are well studied (Larsen, 1991) and thus making them a suitable model organism to study. Butterfly farming involves the extraction of female butterflies from the forest for onward breeding at the farms by majority of the breeders for commercial purpose. An early study conducted by Gordon and Ayiemba, 1997) in Arabuko Sokoke Nature Reserve suggested that there had been no adverse impacts since butterfly farming was introduced in 1993.

The aesthetic appeal and positive appreciation of butterflies are almost most studied taxa, this is because of their appeal easy to breed and capture among other factors. The word trade in butterflies alone has been estimated as much as USD\$ 200 Million annually (Boppr'e and Vane-Wright, 2012). The butterfly farming system has been carefully devised to balance aspects of both conservation and trade; particularly to promote habitat conservation and protection; whilst simultaneously providing some income to people in rural area. It is also provides educational opportunities through its strong associations with schools and the general public (IUCN, 1980).

Worldwide, the number of pupae exported runs to several million per annum, with a dollar value to suppliers approximately twice that number. Speculating on a total sale of 5-10 million pupae per annum worldwide, this would represent an annual market value of livestock in the range USD 10-20 million (Morris *et al.*, 1991). About 2 million pupae per year are imported into the European Union (Boppr'e and Vane-Wright, 2012). Since 2000, the average value of pupae exported from Costa Rica exceeded USD 700,000 per year (Rios, 2002; Montero, 2007). Globally, it is estimated that about 40 million people visit butterfly houses and butterfly gardens per year, 26 million in USA alone

(Rios, 2002). Although some believe the industry can make a direct input to conservation (Hughes and Bennett, 1991; Van der Heyden, 1992; Gordon and Ayiemba, 2003; Goh, 2007; Saul-Gershenz, 2009; Sambhu and Van der Heyden, 2010).

Materials and Methods

Study area

The study was carried out in the Nature Reserve of Arabuko-Sokoke Forest, situated in Kilifi County on the Kenyan Coast (Fig. 1). It is located at Gede, South of the Sabaki River and to the North of Kilifi Creek, between 0311 and 0329 S and 3948 and 4000 E.

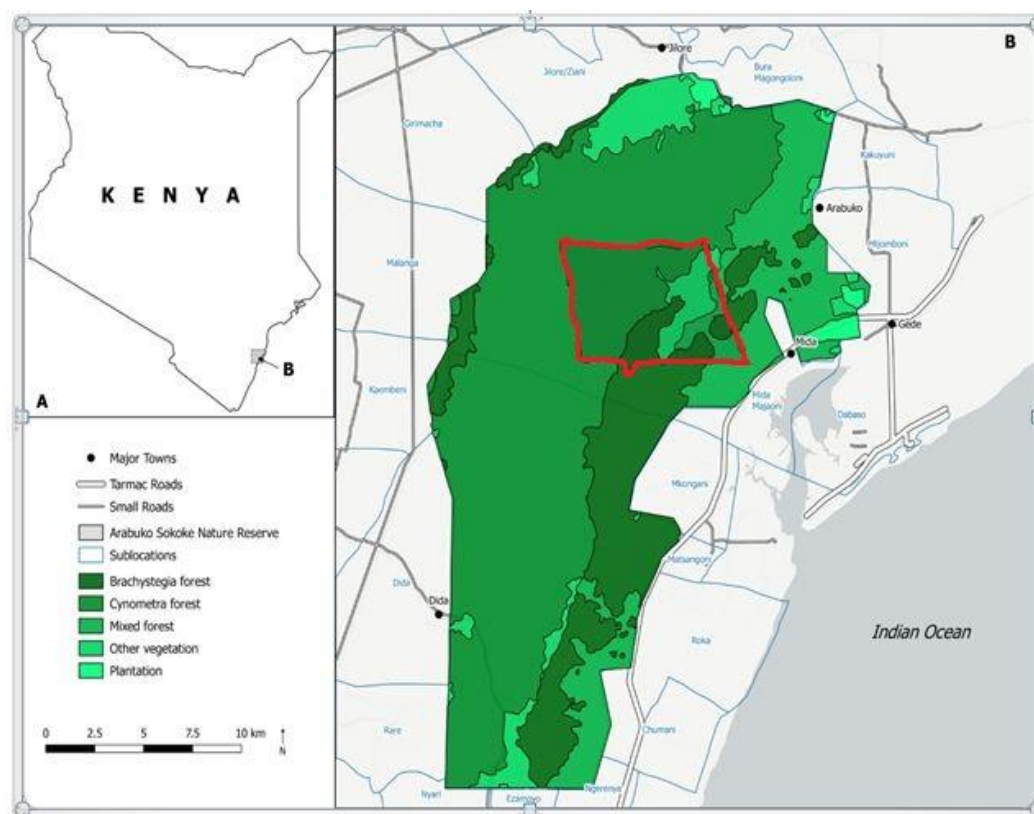


Figure 1: Map of Arabuko Sokoke forest

Habitat categories

Arabuko-Sokoke Forest consists of three different forests as follows;

1. Mixed Forest.

This is a dense forest type which extends to about 7000ha on wetter coastal sands in the east of ASF. This is lowland forest which occupies an area of about 6.5 square km, the forest is dense with nearly continuous canopy as low as 10-12 M and understory of tangled shrubs and small trees with moderate leaf litter.

2. *Brachystegia* Forest.

This is more dense forest covering about 7700ha, dominated by *Brachystegia spiciformis* on drier and infertile white sands through the centre of the forest. This is a form of “miombo” woodland which occupies about 70 km². It is floristically and structurally defined.

3. *Cynometra* Forest.

This is the dense forest or thicket on the north-west side of the ASF covering about 23500ha on the red Magarini sands towards the western side of the forest. It is dominated by trees of *Cynometra webberi*, *Manilkara sulcata*, *Euphorbia* spps, *Brachylaena huillensis* among others. This is a lowland forest covering about 220 square km.

Data Collection Techniques

Butterflies were surveyed in the three different habitat categories selected to be representative of the vegetation types of Mixed, *Brachystegia* and *Cynometra* forest. Data collection took place in 10 months during both the rainy and dry season from May to February 2018, using standard transect lines (Pollard and Yates., 1993; Settele *et al.*, 1999). The sampling was conducted in 96

transects stratified across the three habitat categories, with the highest number of transect being twelve and least with six transects depending on the season. Transition or ecotone of 50m long between different transects was adopted. No recordings were done in the transition area to avoid overlap and double counting. The same protocols and transects earlier used by Ayiamba in 1993 and 1997 to record the species number and occurrence was adopted.

Data Interpretation and Analysis

Data were pooled to obtain total butterfly diversity per study sites and per sampling period and the total butterfly abundances and diversity between sites and between the seasons in each habitat type. The Shannon-Weiner species richness, evenness and diversity indices were computed for each site and for each month.

During the survey, butterfly abundance and composition in the three distinct vegetation types were sampled. Species presence, richness and relative abundance were calculated to track how each site compared with others in a similar habitat, species diversity indices and evenness for each habitat were also calculated.

The cumulative changes in abundance and richness from monthly sampling were assessed to determine peak butterfly sampling periods. The data on species occurrence and abundance from the survey were used to calculate measures of species diversity and evenness.

Results and Discussion

Butterfly composition

A total of 106 species which belong to different 49 genera were recorded in 96 transects. Total of 21,093 butterflies were sighted in the three distinct vegetation type of *Brachystegia*, Mixed and *Cynometra* forest. Five main butterfly families were recorded during the study period (Table 1) and how they were distributed within

the different vegetation type. 98 species were captured from the Mixed Forest, 96 in the *Brachystegia* and 44 from the *Cynometra* zone.

Family	Genera	Species	Composition %
<i>Papilionidae</i>	2	12	11.32
<i>Pieridae</i>	12	30	28.30
<i>Nymphalidae</i>	25	49	46.23
<i>Lycaenidae</i>	7	8	7.55
<i>Hesperiidae</i>	3	7	6.60
Total	49	106	

Table 1: Taxonomic profile of butterflies of Arabuko Sokoke forest Nature Reserve

Butterfly families

Papilionidae

Family *Papilionidae* recorded 2 genera and twelve species about 11.32% of the butterfly recorded during the study. A total of 2011 butterflies from (12) different species were recorded (Table 1) These constitute 9.54% of the total species recorded. Twelve (12) species that belong to the family *Papilionidae* were recorded. The highest number was recorded in *Brachystegia* region, followed by Mixed while *Cynometra* forest recorded the least. All the species were recorded in the 3 different vegetation types except *Papilio dardanus*, *Graphium angolanas* and *Graphium polices* that were absent in *Cynometra* forest.

Pieridae

A total of twelve genera and thirty species were recorded during the study. A total of 8922 butterflies from thirty (30) different species were recorded constituting 42.30% of the total recorded species (Table 1). Members of this family are not among the key species of commercial value. All the species sighted in

Brachystegia forest while twenty three (23) species recorded in mixed forest and fifteen (15) species in *cynometra* forest (Table 1).

Observed Species Richness

Total butterflies observed during the study period were 21,093 in 258 hours. The observed species richness was higher in the *Brachystegia* than in mixed and *Cynometra* forests (Table 2). the high number of butterfly recorded (13245) in the *Brachystegia* forest must have been as a result of the openness of the vegetation as compared to the other two forest sites in the Arabuko-Sokoke Forest (Table 2). The zone has enough radiant energy and the butterfly could freely dart from side within the vegetation zone. The open nature and the stratification of the vegetation also make it a suitable for the nectar flowers to grow thus provide enough nectar source and larval host plants for the larvae. Such habitat attracts both the specialist and generalist species and also the so called savanna species, these being mostly the *Pieridae*. *Brachystegia* also has enough sunlight; direct illumination of the

paths was also far better than the other two sites and therefore must have allowed for greater butterfly activity. The stratification manifests itself well in

Brachystegia hence provide variety of plant form and support several larval host plants.

	Species	Brach	No. of records	Cyn o	No. of record	MF	No. of record	Total no. of records	Rank 2017
1.	<i>Papilio constantinus</i>	+	96	+	58	+	75	229	34
2.	<i>Papilio dardanus</i>	+	99	-	0	+	58	157	55
3.	<i>Papilio nireus</i>	+	104	+	40	+	71	215	37
4.	<i>Papilio demodocus</i>	+	210	+	78	+	129	417	10
5.	<i>Graphium philonoe</i>	+	46	+	9	+	28	83	79
6.	<i>Graphium leonidus</i>	+	28	+	2	+	15	45	94
7.	<i>Graphium kirbyi</i>	+	22	+	3	+	10	35	100
8.	<i>Graphium Colonna</i>	+	192	+	25	+	99	316	19
9.	<i>Graphium antheus</i>	+	176	+	43	+	74	293	24
10.	<i>Graphium porthaon</i>	+	41	+	18	+	20	79	80
11.	<i>Graphium angolanus</i>	+	37	-	0	+	19	56	88
12.	<i>Graphium policeses</i>	+	20	-	0	+	17	37	99
13.	<i>Dexia charina</i>	+	51	+	6	+	52	106	70
14.	<i>Catopsilia florela</i>	+	423	+	55	+	201	679	2
15.	<i>Pinacopteryx eviphia</i>	+	178	+	119	-	0	297	22
16.	<i>Nephronia thalassina</i>	+	373	-	0	+	189	562	6
17.	<i>Eronia cleodora</i>	+	361	+	74	+	204	639	3
18.	<i>Colotis regina</i>	+	502	-	0	-	0	502	8
19.	<i>Colotis ione</i>	+	201	+	56	+	136	393	12
20.	<i>Colotis euippe</i>	+	193	-	0	+	124	317	18
21.	<i>Colotis eris</i>	+	154	+	12	+	58	224	36
22.	<i>Colotis auxo</i>	+	223	-	0	+	133	356	14
23.	<i>Belenois creona</i>	+	144	-	0	+	152	296	23
24.	<i>Belenois gidica</i>	+	149	+	27	+	98	274	26
25.	<i>Belenois thysa</i>	+	182	+	45	+	99	326	17
26.	<i>Appias epaphia</i>	+	126	+	47	+	55	228	35
27.	<i>Leptosia alcesta</i>	+	279	+	88	+	114	481	9
28.	<i>Eurema regularis</i>	+	19	-	0	+	9	28	102
29.	<i>Mylothris agathina</i>	+	346	+	38	+	186	570	5
30.	<i>Dannaus chrysippus</i>	+	132	+	33	+	69	234	32

31.	<i>Amauris niavius</i>	+	75	+	12	+	46	133	62
32.	<i>Amauris ochlea</i>	+	66	-	0	+	42	108	71
33.	<i>Melanotis leda</i>	+	189	+	38	+	112	339	16
34.	<i>Bicyclus safitza</i>	+	148	+	33	+	79	260	28
35.	<i>Ypthima astrope</i>	+	45	+	3	+	30	78	82
36.	<i>Euryphura achlys</i>	+	71	+	7	+	38	116	66
37.	<i>Bebearia chriemhilda</i>	+	189	+	19	+	98	306	20
38.	<i>Euphaedra neophron</i>	+	199	+	6	+	68	273	27
39.	<i>Byblia ilithyia</i>	+	127	-	0	+	80	207	39
40.	<i>Eurytela dryope</i>	+	87	-	0	+	47	134	61
41.	<i>Hypolimnas misippus</i>	+	476	+	24	+	251	751	1
42.	<i>Hyplimnas deceptor</i>	+	172	+	96	+	76	344	15
43.	<i>Hypolimnas anthedon</i>	+	111	+	12	+	71	194	43
44.	<i>Salamis anacardii</i>	+	159	+	38	+	79	276	25
45.	<i>Junonia oenone</i>	1	347	+	86	+	190	623	4
46.	<i>Junonia hierta</i>	1	42	+	9	+	28	79	80
47.	<i>Junonia natalica</i>	1	94	+	28	+	58	180	49
48.	<i>Junonia terea</i>	1	0	-	0	+	119	119	64
49.	<i>Phalanta phlantha</i>	1	259	+	22	+	246	527	7
50.	<i>Pardopsis punctatissima</i>	1	53	-	0	-	0	53	89
51.	<i>Pseudacraea lucretia</i>	1	67	-	0	+	19	86	77
52.	<i>Charaxes varanes</i>	1	46	+	27	+	38	111	69
53.	<i>Charaxes candiope</i>	1	49	+	17	-	0	66	84
54.	<i>Charaxes Cithaeron</i>	1	84	-	0	+	51	135	60
55.	<i>Charaxes protoclea</i>	1	43	-	0	+	55	98	75
56.	<i>Euxanthe wakefieldii</i>	+	35	-	0	+	22	57	87
57.	<i>Tirumala petverana</i>	+	32	-	0	+	19	51	91
58.	<i>P.boisduvali</i>	+	32	-	0	+	15	47	93
59.	<i>Herma theobene</i>	+	0	-	0	+	66	66	84
60.	<i>Charaxes lasti</i>	+	74	-	0	+	34	108	71
61.	<i>Charaxes castor</i>	+	72	-	0	+	43	115	68
62.	<i>Charaxes jahlnusa</i>	+	38	-	0	+	34	72	83
63.	<i>Charaxes guderiana</i>	+	90	-	0	-	0	90	76
64.	<i>Charaxes brutus</i>	+	81	-	0	+	43	124	63
65.	<i>Charaxes violetta</i>	+	48	-	0	+	12	60	86
66.	<i>Charaxes zoolina</i>	+	48	-	0	+	38	86	77

67.	<i>Eurema hecabe</i>	+	68	+	18	+	31	117	65
68.	<i>Eurema brigitta</i>	+	108	-	0	-	0	108	71
69.	<i>Nephronia argia</i>	+	94	-	0	+	49	143	57
70.	<i>Eronia leda</i>	+	156	+	97	-	0	253	29
71.	<i>Colotis antivippe</i>	+	90	-	0	+	79	169	52
72.	<i>Colotis amatus</i>	+	74	-	0	+	86	160	54
73.	<i>Colotis vesta</i>	+	118	-	0	+	98	216	37
74.	<i>Colotis danae</i>	+	111	-	0	+	97	208	38
75.	<i>Colotis daira</i>	+	177	-	0	-	0	177	50
76.	<i>Colotis evagore</i>	+	183	-	0	-	0	183	48
77.	<i>Colotis evinina</i>	+	192	-	0	-	0	192	44
78.	<i>Belonois aurota</i>	+	409	-	0	-	0	409	11
79.	<i>Appias Sabina</i>	+	97	+	18	+	74	189	45
80.	<i>Appias lasti</i>	+	61	+	12	+	34	107	73
81.	<i>Physeueresia leda</i>	+	26	-	0	-	0	26	103
82.	<i>Neptis laeta</i>	-	0	-	0	+	41	41	96
83.	<i>Neptis serena</i>	+	10	-	0	+	19	29	101
84.	<i>Neptis trigonophora</i>	-	0	-	0	+	37	37	98
85.	<i>Neptis melicerata</i>	+	15	-	0	+	6	21	105
86.	<i>Neptidopsis fulgurata</i>	-	0	-	0	+	23	23	104
87.	<i>Acraea equitorialis</i>	-	0	-	0	+	18	18	106
88.	<i>Acraea natalica</i>	-	0	-	0	+	38	38	97
89.	<i>Acraea rabbaea</i>	+	27	-	0	+	21	48	92
90.	<i>Acraea eponina</i>	+	22	+	16	+	15	53	89
91.	<i>Acraea anemosa</i>	-	0	-	0	+	44	44	95
92.	<i>Pentila tropicalis</i>	+	245	-	0	-	0	245	31
93.	<i>Baliochila hildergarda</i>	+	98	-	0	+	1	166	53
94.	<i>Baliochila minima</i>	+	134	-	0	+	1	231	33
95.	<i>Lolaus diametra</i>	+	200	-	0	-	0	200	42
96.	<i>Hypolycaena phillipus</i>	+	183	-	0	-	0	183	47
97.	<i>Leptotes pirithous</i>	+	247	-	0	-	0	247	30
98.	<i>Zizula hylax</i>	+	184	-	0	-	0	184	46
99.	<i>A.amanga</i>	+	116	-	0	-	0	116	66
	100.Coaciliades anchises	+	124	+	53	+	28	205	40
	101.Coaciliades sejunta	+	117	+	32	+	54	203	41
	102.Coaciliades keithloa	+	214	-	0	+	174	388	13

103.Coprana pillaana	+	303	-	0	-	0	303	21
104.Borbo detecta	+	131	-	0	+	40	171	50
105.Borbo gamella	-	0	-	0	+	154	154	56
106.Coaciliades forestans	+	86	-	0	+	53	139	58
TOTAL		13245		1599		6249	21093	

Legend: + Present: - Absent

Table 2: Butterfly Abundance and Distribution with determined attributes.

Species name, Habitat category where the species was observed (**Brach**= *Brachystegia* woodland, **Cyno**= *Cynometra* forest, **MF**= Mixed forest) with + = species occurs in the habitat category, - = species does not occur in the habitat category; Number of recorded species in each habitat category.

A total of six (6) species that belong to sub-familiy *Acraeinae* were recorded. All of this species were sighted in the mixed forest except *Pardopsis punctatissima*. Only one (1) species was recorded in *Cynometra* forest and the other five species not recorded.

Family	Mixed	%	Brachystegia	%	Cynometra	%	All	%
<i>Papilionidae</i>	615	9.85	1120	8.46	276	17.26	2011	9.53
<i>Pieridae</i>	2368	37.90	5842	44.11	712	44.53	8922	42.30
<i>Nymphalidae</i>	2598	41.58	3901	29.46	526	32.90	7025	33.30
<i>Lycaenidae</i>	165	2.64	1407	10.65	0	0	1572	7.45
<i>Hesperiidae</i>	503	8.05	975	7.37	85	5.32	1563	7.41
TOTAL (N)	6249		13245		1599		21093	
TOTAL %	29.6		62.7		7.5			
TOTAL hour	98		110		50		258	
No.per hours	63.76		120.4		31.98			

Table 3: Butterfly Abundance (family) in Different vegetation zone

Seven (7) species of the subfamily *Lipteninae* were recorded. None was recorded in mixed forest. All were sighted in the *Brachystegia* forest except *Leptotes pinthous*. Out of the seven species only two *Baliochila*

hildergarde and *Baliochila minima* were sighted in *Cynometra* forest. Three (3) species of the subfamily *Hesperinae* were recorded of which no sighting was made in *Cynometra* forest (Table 3). changes were observed to result in change in the number of species and individuals (Table 4).

Butterfly Seasonality

The seasonality effect on abundance and distribution both in rainy and dry weather condition were tested;

Period/Weather condition	Family					
	<i>Papilionidae</i>	<i>Pieridae</i>	<i>Nymphalidae</i>	<i>Lycaenidae</i>	<i>Hesperidae</i>	Total
May-Aug	909	4695	3774	893	916	11187
Sept-Oct	484	2326	1849	411	408	5478
Nov- Dec	447	1655	1360	247	221	3930
Jan-Feb	122	236	101	21	18	498
Total	1962	8912	7084	1572	1563	21093
Percentage (%)	9.30	42.25	33.58	7.45	7.41	

Table 4: Seasonal trends of Butterfly (families) Abundance during the study period.

The highest records for all the butterfly families were during the rainy period of (May- August), 11187 butterflies sighted. During the months of November and December the records shows dropped to 3930 butterflies for all the families counted when compared with the month of May - August. Total decline of numbers during the dry period of the month of January and February was noted, only 498 butterfly recorded (Table 4). The low records was due to the poor condition of the forest, high temperature coupled with dry and hard foliage which is not palatable and not preferred by larval instars in the initial stages of development as the

leaves have less moisture content and the larvae also lack proper chewing mandibles.

Seasonal changes in the total number of butterflies recorded

During the entire study period the highest number of counts was in the month of July, where the average number of individuals sighted was 3001. November came second followed by September. The lowest count was that in the month of February with 123 butterflies recorded (Table 4).

Month	Total	Percentage %
May	2683	12.72
June	2787	13.21
July	3001	14.23
August	2716	12.88
September	2585	12.26
October	2653	12.58
November	2805	13.30
December	1125	5.33
January	375	1.78
February	123	0.58
Total	21093	

Table 5: Total monthly records for the study sites

The trend of change in abundance in the three different zones did not have highest peaks on the same month as that for all the zones combined. The Mixed Forest had highest number of individuals in May, the *Brachystegia* Zone in June and the *Cynometra* Zone in August (Table 5). Lowest numbers of counts recorded in February for the Mixed Forest and *Brachystegia* zones while for *Cynometra* was in March.

Monthly records per family for the study sites

Changes in butterfly populations are often correlated with the condition of habitat, extreme weather events and changes in plant community composition affecting the quality and abundance of larval host plant and nectar sources. There is a positive association between the butterfly and the plant community which acts as the main food for larvae and also as a source of nectar for adult butterflies (Table 6).

Month	Family %				
	<i>Papilionidae</i>	<i>Pieridae</i>	<i>Nymphalidae</i>	<i>Lycaenidae</i>	<i>Hesperiidae</i>
May-Aug	8.13	41.97	33.74	7.98	8.19
Nov-Dec	11.37	42.11	34.61	6.28	5.62
Sept-Oct	8.84	47.94	33.75	7.50	7.45
Jan-Feb	24.50	47.39	20.28	4.22	3.31

Table 6: Total Monthly records per family for the study sites

Species diversity indices

The lowest species richness values were recorded in the months of February for the entire three habitats while the highest values recorded in the months of July and followed by November in the mixed forest. The Shannon-diversity indices $H' = 4.19722$ while evenness was $E' = 0.915$ in mixed forest. *Brachystegia* forest recorded the lowest indices in February for the all transects. Species richness and high indices recorded in

July and followed by august. The Shannon-diversity indices was $H' = 4.30688$ and evenness $E' = 0.943$. *Cynometra* forest had the lowest species richness recorded in different months for the three transects, February, January and December. However all the three transects had their highest species in July. Shannon-diversity indices of $H' = 3.50084$ and Evenness of $E' = 0.925$ (Table 7).

Site	Shannon index (H')	Evenness (E')
Mixed Forest	4.19722	0.915
<i>Brachystegia</i> Forest	4.30688	0.943
<i>Cynometra</i> forest	3.50084	0.925
Overall	4.381	0.949

Shannon-Weiner indices were calculated, where larger numbers indicate greater species diversity and evenness.

Table 7: Species diversity indices

Discussion

Representation of Families

The family *Pieridae* recorded the highest number of butterflies comprising of 42.25% of the total counts, followed by *Nymphalidae* with 33.58%, *Papilionidae* with 9.30%, *Lycaenidae* with 7.45% and *Hesperiidae* with 7.40%. This low counts for family *Lycaenidae* and *Hesperiidae* could have resulted from their being under sampled due to the difficulty of their capture and identification in flight. Sweep netting could have been biased towards the larger that are more easily identified either in flight or in traps. All the five families that have been recorded by Larsen (1991) were captured during study's inventory which is *Papilionidae*, *Nymphalidae*, *Pieridae*, *Lycaenidae* and *Hesperiidae*. Ninety eight (98) species were recorded in the Mixed forest, 96 species in the *Brachystegia* while 44 species in the *Cynometra* forest. The species composition of the

study site generated results of 21,093 butterflies and 106 species from 5 families in a total of 258 hours (Table 2).

The results illustrated (Table 2) Species distribution in each habitat category; however this does not mean that their ranges were only confined to these habitats. At times positive identification was not possible for species occupy top canopy. This was very common with genus *Charaxes*, and *Acraea*. The habitats indicated in (Table 2) were restricted to only those in which butterfly species were sighted or captured during the survey. The butterfly community composition differed in morphological features between the seasons, particularly visible by the high proportion of large winged butterflies during the rainy season (Habel *et al.*, 2018).

Habitat preference

There were differences in the butterfly species richness and abundance in the three habitat categories. Therefore, most likely the butterfly species had different forest habitat preferences for host plants and habitat conditions. The vegetation structures in the habitat categories could be responsible for the differences in the butterfly species composition (Table 2).

The results support what other researchers have found in that butterfly species abundance and richness tend to be influenced and respond to local vegetation characteristics (Simonson *et al.*, 2001, Collinge *et al.*, 2003, the butterfly farming had no adverse effect on butterfly population (Gordon and Ayiemba, 2003). Different habitats contribute more to butterfly species diversity than others (Habel, *et al.*, 2018). The presence of water also contributes to the potential for greater butterfly diversity and richness through its positive effects on associated vegetation and provides support for other butterflies behavior like puddling (Habel *et al.*, 2018).

The favorable conditions that enabled the butterflies to increase in numbers may have also led to increase in abundance of their natural enemies and competitors in the food chain. The climatic conditions have also contributed to increase of its natural enemies, predators and parasitic organisms. Fluctuations in abundance of the butterflies may be caused by the resource partitioning patterns in time that occur between inter or intra-specific competitions and hence lead to expansion of home range by some species while others overlap.

The market demand of certain species is regarded as a key factor to the abundance and composition of the species. If butterfly is desirable, pretty, highly attractive, active flier and highly priced is most likely to be

targeted for commercial purpose as compared to those which have dull colors, short pupation period and not good flier in captivity.

The availability of nectar sources correlates with the distribution of adult butterflies while flowering plant species richness influences the variation of butterflies while the flowering plants species richness influences the variation of butterfly species richness (Sena, 2017).

Normally insects have high fecundity during the wet season and drop during dry seasons within the tropics (Owen, 1975). In Arabuko-Sokoke the peak abundance occurred during the months of May-August was as high as individuals per hour. The *Brachystegia* had an average of 120.40+, The Mixed forest 63.76+ and *Cynometra* 31.98+. The dry months of January and February recorded the lowest individuals

Conclusion and Recommendations

The preliminary assessment of butterfly diversity in Arabuko Sokoke forest nature reserve adds to the evidence that the forest harbors diverse species of butterfly. It support a good population of five different resident family of butterfly. The study revealed also that a favorable weather conditions are the main determinants of a good butterfly population stock. The butterflies are evenly distributed within the three distinct habitats within the study site. The generalist's species are widely distributed than the forest specialist. The study concludes that the level of destruction and disturbance on vegetation have impacts; the results and other study indicate that the enforcement of government policy on forest protection has been weak and need strengthened. There is need to ensure that habitat diversity within ASF needs to be protected since such diversity increases the abundance and presence of many taxa of significance.

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