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Taxonomy and Diversity of Vascular Plant Species in Cherangani Forest of Marakwet West in Kenya

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Abstract

The availability of accurate and sufficient information on plant taxonomic groups and similarity measures is crucial for making informed conservation decisions. In many forests, due to human population pressure, many species face the risk of extinction, some of which could be possessing solutions to numerous problems facing mankind. However, due to inaccessibility caused by extreme isolation and harsh conditions, little research has been done in this field on plants in Cherangani forest station. This study focused on the numbers of various plant taxa and their distribution in Cherangani done in blocks with a view of developing a management database. Standard botanical inventory and Herbarium protocols were used and analysed using a Microsoft Excel spreadsheet. Eight hundred and fifteen (815) species in 129 families and 450 genera respectively were identified. This is an indication that this flora is one of the richest in the country hence a priority conservation spot. Additionally, the blocks vary in species numbers and growth forms, therefore, necessitating varied management.

Keywords: Taxonomy, Diversity, Vascular Plant Species, Cherangani Forest, Marakwet West

INTRODUCTION

Past and recent studies have demonstrated that Eastern Africa Afromontane regions that include Cherangani hills, constitute the tenth most species-rich area in the world both in overall and remaining natural vegetation (Sosef et al., 2017). More so recently, some studies have recommended that both species endemism and richness can be used as the main criteria to set priorities in species conservation (Bruijnzeel et al., 2011). This is because it's necessary to understand the present diversity status and conservation of forest flora (Coria & Sterner, 2011). However, due to population pressure in these regions, a decline of native forest cover even within conserved areas has been experienced (Kindt et al., 2014). Again, due to inaccessibility caused by extreme isolation and harsh conditions, little research has been done on plant species inventory (Sosef et al., 2020). Such knowledge gaps have in the past complicated several sustainable conservation projects in ecosystems (Abayneh et al., 2017). Up to today, no previous study has focused on the distribution of plants and their taxonomic groups in Cherangani forest station blocks. This has prompted stakeholders to seek organized conservation knowledge.

The plant taxa information is important for several reasons (Raimondo et al., 2015). Firstly, it is vital for ecologists when describing plant communities in terms of the number of species present, and their relative abundance (Aggemyr et al., 2018). Ecologists can utilize such information to underpin the overall health of an ecosystem (Brusati et al., 2014). Similarly, the composition of the plant community can inform us about the quality of the habitat for instance if wet, have a high or low nutrient load, or are heavily grazed (Bascompte & Rodriguez, 2001). Again, knowing threatened species and where they occur now as well as in the future is crucial to spending conservation resources efficiently and effectively (Coria & Sterner, 2011). Secondly, we need to know what exists, and where to determine how we can conserve and use it (Zhu et al., 2015). Thirdly, its use in evaluating the impact of previous forest activity (Masters, 2014). Finally, It can indicate the capability of forest recovering from past disturbances (Phongoudome et al., 2013), thus, can be used for planning and better management of forests on a sustainable basis.

Notwithstanding centuries of taxonomic effort, characterization of plant species composition remains a substantial and important challenge (Rouhan & Gaudeul, 2014). This is partly attributed to the fact that although plants are fairly well understood compared to other groups like insects, recent estimates suggest that nearly 70 000 angiosperms are not described (Balke et al., 2013). Beyond finding these new species, existing taxonomic accounts need reconciling and updating (Spracklen & Righelato, 2014). This is because, frequently when some of these groups are revised, numerous and often radical changes sometimes have to be made, resulting in a relatively high incidence of changes in names and concepts (Lastrucci et al., 2014). Although frequent name changes have been cited as one of the drawbacks that make plant taxonomy a cumbersome field to follow (Cook et al., 2015), it was suggested by Sharma & Kant (2014) that periodic surveys and reviews of existing names in literature ensure continuous harmonization of names between users.

A major effort to document the plants of Kenya was captured in the Flora of tropical East Africa (FTEA 1948-2012). The study involving 135 botanists from 22 countries compiled monographs, identification manuals and taxonomic treatments in a single flora. Traversing different vegetation zones, the team managed to document 12104 native *spp*, 2500 of which are found nowhere else. Additionally, the study described 1500 *spp.* new to science, 114 of them discovered within the last four years (*State of the World's Plants and Fungi 2020*). Based on more than a million specimens preserved in many herbaria it's arguably the largest regional study. The single most limitation of this study is that the published fascicles have been superseded by current classification systems with many *spp.* described after some publications (The Angiosperm Phylogeny Group, 2016). In addition, several species have been described, revised and probable some have gone extinct (Lastrucci et al., 2014). This makes it difficult to work alongside modern schemes, this has raises concerns in the post FTEA analysis to have radical revisions and studies in the region (Kew, 2006).

After the FTEA, a simplified summary of taxa in East Africa (Bytebier, 2008) and Kenya (Zhu et al., 2017) based on parent study was presented. The later focused on analysing the vascular plants in Kenya. The authors converted their findings to the recent molecular systematic to develop a "Synoptic List of Families and Genera of Kenyan Vascular Plants (SLFGKVP). Concurrently, a few local studies have attempted to register all plants *spp.* in areas regarded as biodiversity hot spots in Kenya. In Taita hills, a leading inventory reported 1396 plant taxa in 145 families and 686 genera (Luke, 2005). This represents 44% of the coastal flora and 21% of the Kenyan flora. In Aberdare, Kipkoech et al. (2020) listed 1337 spp., while in Nandi, Kipkoech et al. (2020) registered 686 plant spp. additionally, Girma et al. (2014) recorded 321 spp after a similar work there. Zhou et al. (2018) recorded 1335 *sp*. in Mt. Kenya. In Nakuru national park, over 575 vascular plant *spp.* were recorded (Mutangah, 1996). Similarly, in Kakamega 986 spp were recorded (Fischer et al., 2010) Previously in the same forest, a survey had revealed about 400 vascular taxa (Althof 2005). One weakness with the study of Fischer et al. (2010) was that it took a long (8 years) to conclude (p.138 par.2), hence it was subject to fail in recognizing newer names and concepts.

In Cherangani forest station, plants have been captured by very few studies in the first instance, the Kenya trees shrubs and lianas (KTSL) attempted to document National woody plants (Beentje, 1994). One limitation on this pivotal literature is lack of subsequent editions, being out of print and stock. This implies that this literature is fairly outdated considering that so many species have been described in the recent past (Rakotoarisoa et al., 2016). Another study in Kenya (KIFCON, 1994) focused on providing estimates of forest areas and total standing volume by species. This study's main limitation was confinement to only trees of known merchantable value. About non-wood vascular plants, Cherangani forest is satisfactorily covered by Upland Kenya wildflowers (UKWF). That covers high potential Kenya previously published in 1993 then republished in 2013 by Agnew. The book provides the most dependable treatment of over 3000 species including herbs, ferns and graminoids. However, the book does not cover the entire country, particularly the coastal flora which possess highest species diversity.

Arguing from the basis that, in the present state of knowledge, updated and comprehensive studies on the flora of Cherangani are obscure in literature. These pertinent concerns have prompted the necessity of the current study to provide a platform for future studies and guide in developing conservation guidelines and strategies. Therefore, the main aim of this study was to understand flora of Cherangani forest station. This has been achieved by answering the following questions: Number of species, lower taxonomic ranks of species, what are the life forms and how are they distributed? This study adds to the existing knowledge about the ecosystem and will be an invaluable resource to researchers, workers on plants and students in the plant sciences in general.

METHODOLOGY

Study Area

Cherangani ecosystem is comprised of a series of forest reserves, about 15 forest blocks, approximately 95,600 ha in the gazetted area (Birdlife International, 2009). The specific five blocks that comprise Cherangani forest station are located on the western part of the entire ecosystem having more or less 15 isolated blocks. The study area is mostly mountainous comprising Kerrer, Koisungur, Toropket, Chemurgoi and Kipteber (Figure 1). The blocks are located in Rift Valley province within an area bounded by 1^{o} 51' to 1^{o} 19' N and 35^{o} 29' to 35^{o} 43' E.

The forest can be accessed from Eldoret Town via road to Kachibora then branch to Kapcherop which is the nearest market center to Cherangani forest station.

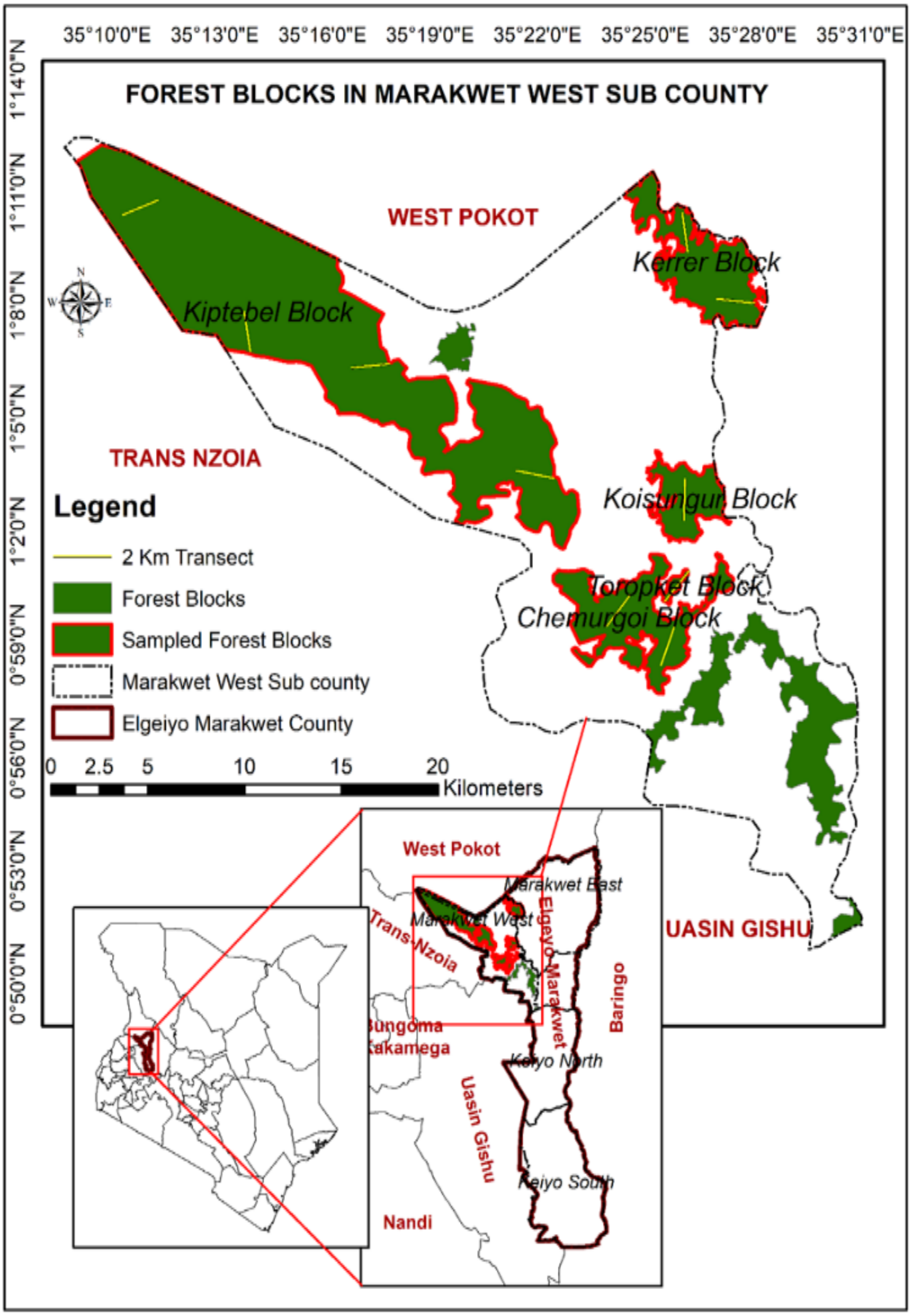

Figure 13: Map of Marakwet West showing position of Cherangani Forest Station.

Research Design

The primary method of investigation was exploratory surveys guided by linear transects (Gillison, 2006). Inventory of the plant species was undertaken in ten transects (10 m wide and totaling 20 km long) separated by at least 5 km (Gonçalves & Goyder, 2016). This amounts to about 1% of the total area. The transects were located well inside the forest and times extended to the forest margins.

Taxonomic Data collection was done according to standard protocols (Rabeler et al., 2019; Forman & Bridson (Eds), 1999). Identification was done using standard references (Agnew, 2013; Beentje, 1994; FTEA Fascicles 1948-2012) together with virtual herbaria (POWO.science.kew.org; IPNI). Regional floras and field keys were equally employed. Due to limited updated previous botanical work in the region, it was not possible to name all collections made, particularly sterile material, but the majority of them were determined to species level in the field. This is important because field identification enables investigators to notice the risk of extinction or the arrival of invasive species and follow the changes in biodiversity over time. In cases of plants not unidentified in the field, herbarium specimens were prepared and presented to experts for assistance in identification and comparison with collections at the East Africa herbarium (EA) and the University of Eldoret herbarium. Copies have been deposited at the University of Nairobi Herbarium (NAI).

RESULTS

Plant Species in Major Groups

Eight hundred and fifteen (815) species in 128 families and 450 genera were classified in seven growth habits and eight biogeographical affinities (Fig 4). Almost 60% of all plant families and 12.3% of all spp natives in Kenya are present in Cherangani. The proportion of exotic families stands at 25.8% of alien families with only 8.5% spp. compared to national tallies (Table 1). The majority of the species are eudicots and monocots consisting of 92% of the total species composition. There are 145 Pteridophytes. One magnolid, 3 lycophytes, 7 gymnosperms, and no basal angiosperms (Table 2).

Table 1: Number of vascular taxa of Cherangani forest station compared to National records

		Kenya	Cherangani	Percentage
Indigenous	Families	225	128	56.4
	Genera	1538	450	29.3
	Species	6293	765	12.3
Exotic	Families	62	16	25.8
	Genera	302	39	12.9
	Species	588	50	8.5
	Total species	6881	815	11.84

Table 2: Major groups of plants are identified by numbers and percentage of all species counts

Plant group	Number of species	As % of the total count
Lycophytes	3	0.0037
Gymnosperms	7	0.086
Monilophytes	138	16.9
Magnolids	1	0.0012
Basal angiosperms	0	0
Eudicots	618	75.8

Species Diversity (Richness)
Kipteber block had 91.6% of all species represented while Toropket had the least number of species at 15.1% of all counts (Fig.2). By density, Kerrer had the highest at 110.2 spp/km^2(Fig.3).

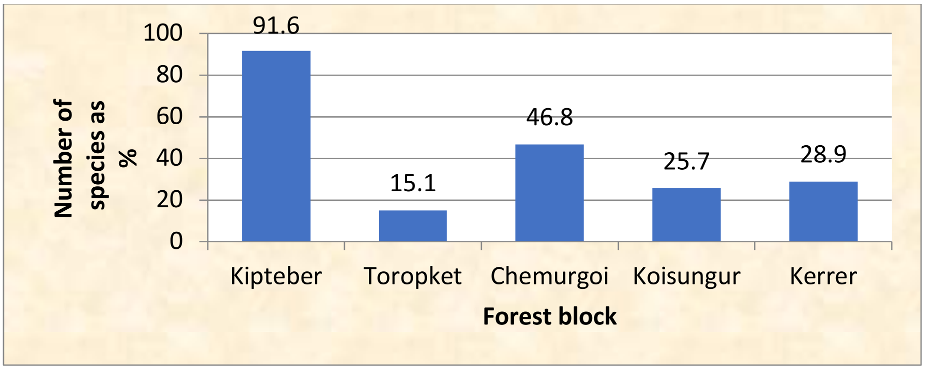

Figure 1: Species in blocks as a percentage of all species.

Plant Growth Habits
Most of the species grow as seasonal herbs accounting for 49.4% of all registered plants. Woodyplants comprise about 29% with the rest being epiphytes, graminoids and perennial herbs (Figure 4-6).

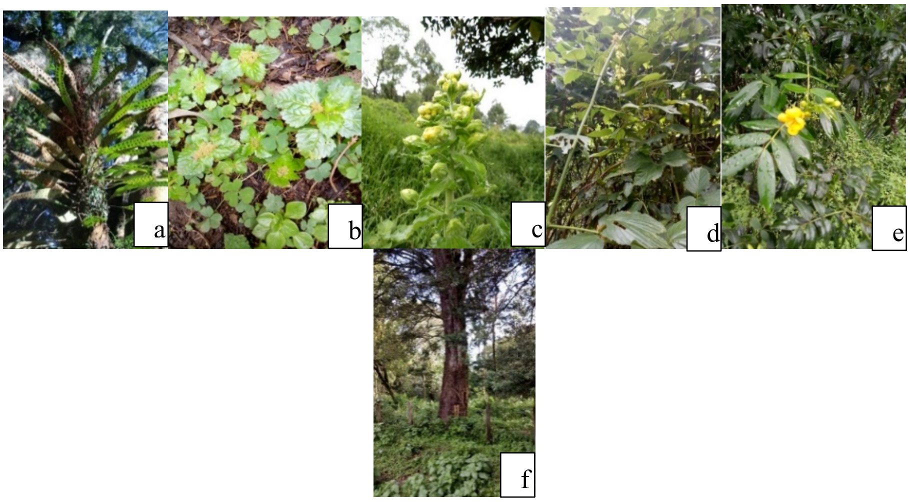

Plate 1: Seasonal herbs: a. *Lepisorus excavatus*, b. *Pilea tetraphylla*, c. *Verbascum brevipedicellatum*, e. *Senna septemntrionalis*, (Shrub) f. *Afrocarpus gracillior* (Tree), d. *Gouania longispicata* (Climber).

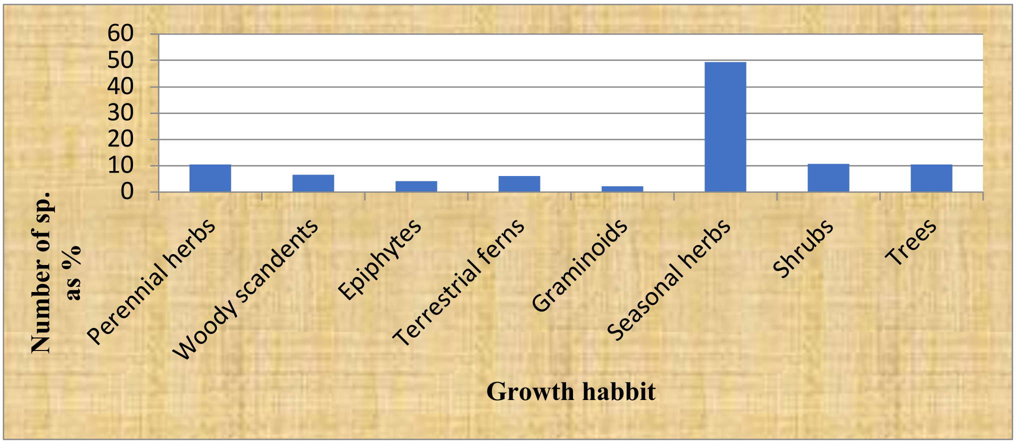

Figure 2: Number of species per growth habit as a percentage of total counts in Cherangani Forest.

The number of trees species. is almost the same in all blocks with exception of Kipteber. Fifty of the identified species of plants are not native to Kenya. This is equal to 6% of the entire species population. The majority of these introduced plant species are from America with a few from Australia, Europe, Asia and South Africa (Figure 2).

Biogeography of Species

Species associated with disturbed habitats and wooded grasslands have the highest numbers in all blocks, followed by moist montane spp. Kipteber had twenty species deliberately introduced (local or alien) and Koisungur had one species. Other blocks did not have planted exotics plant species (Figure 3).

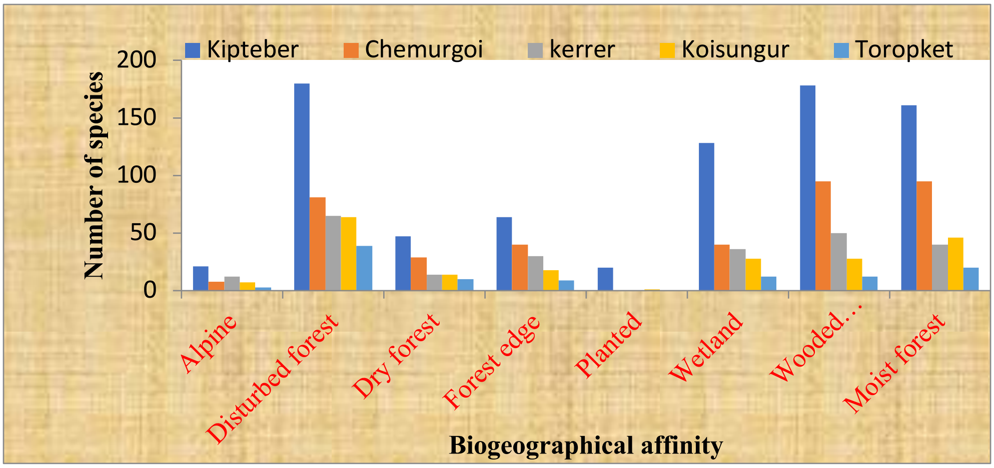

Figure 3: Distribution of species according to biogeographical affinity in blocks.

Largest Families and Groups

The ten largest families constitute 49% of all spp. Asteraceae and Orchidaceae are the most dominant families with Solanaceae and Euphorbiaceae being the least. The remaining 118 families account for 54% of all inventoried species (Figure 5).

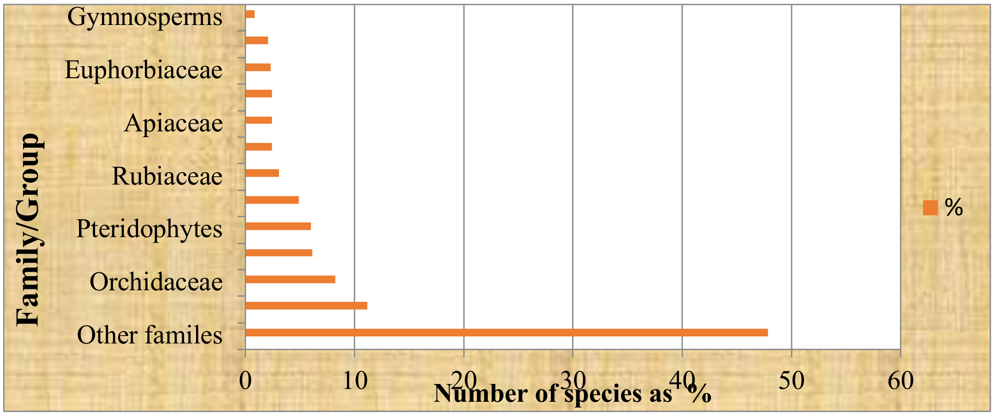

Figure 4: Occurring largest Families and groups with % of Spp. sorted after their dominance.

New Records (Novelties)

The current research identified no species new to science, however, three species, *Calceolaria tripartita* (Plate 4.1), *Petunia species* and *Nothoscordum borbonicum* are new records of Cherangani and Kenya (Plate 4.2). In addition, eight other species are reported for the first time in Cherangani but are common in other parts of Kenya (Table 4.4).

Table 3: New records of species in Kenya and Cherangani

Family	Species	Remarks
Convolvulaceae	*Petunia sp*	New record in Kenya Last reported by Mabberley (P.9), in 1975.
Euphorbiaceae	*Euphorbia obovalifolia*	Turning invasive around Tenden & Kapcherop.
Hypericaceae	*Harungana magascariensis*	1st record in Cherangani
Fabaceae	*Acrocarpus fraxinifolius*	1st record in Cherangani
Fabaceae	*Fraxinus pennyslivanica*	First record in Cherangani
Canellaceae	*Warburgia ugandensis*	1st record in Cherangani
Martaceae	*Lophostemmon confertus*	1st record in Cherangani
	Pinus radiata	1st record in Cherangani plantation sp in Koisungur
Fabaceae	*Senna septemntrionalis*	First record in Cherangani possible invasive.in Chemurgoi
Calceolariaceae	*Calceolaria tripartita*	First record in Kenya. East Africa (Probably Africa).
Amaryllidaceae	*Nothoscordum borbonicum*	Serious weed in tree nursery First record in Kenya

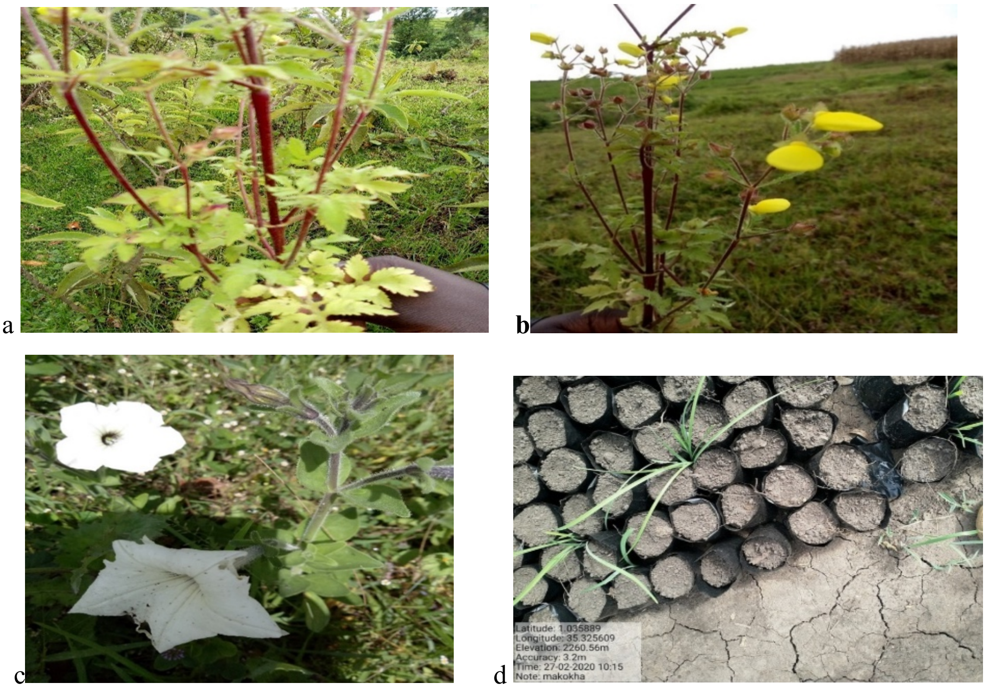

Plate 2: *Calceolaria tripartita* leafy stem (a) and flowering (b) in Kapcherop *Petunia* species. (c) *Nothoscordum bobornicum* in Cherangani Forest Nursery (d).

DISCUSSION

In an attempt to describe taxonomic groups of vascular flora and document the entire vascular flora of Cherangani, an extensive exploratory survey was employed leading to documentation of 815 species registered in 450 genera and 128 families. This accounts for 11.84% of Kenya's vascular plants, 56.4% and 29.3% for families and genera respectively. Asteraceae and Orchidaceae are the most populous families while herbaceous plants constitute (61%) the growth habits where most plant species lie. By habitat, most spp. are associated with disturbed ecosystems, moist Afromontane, or wooded grasslands. Among the blocks, Kipteber and Toropket are the most and least diverse at 748 and 123 spp., respectively.

The studied plant groups in terms of relative representation (Table 1) and in major taxonomic grouping (Table 2) mirror several studies (Luke, 2005; Zhou, 2018). The findings demonstrate that the flora of Cherangani is rich in taxa at various ranks between family and spp. This species population accounts for the country's 12.3 %, and 56.4% of all native plant spp. and families respectively (Zhou et al., 2017). In addition, most of the spp. are native to the ecosystem (91.5%). A comparison with recent studies confirms that the forest is sixth countrywide in plant species richness only inferior to Kakamega, Mt. Kenya, Aberdare and Shimba forests (Fischer et al., 2010; Luke, 2005; Zhou, 2018). This demonstrates that Cherangani with other water towers are spp. richest regions in the country. Recent surveys in the current study area that yielded only 176 and 133 spp (Musila et al., 2011) can be attributed to rapid methods used, seasonality of some spp, or sampling bias (Groom & Whild, 2017). A similar study (Mbuni et al., 2019), recorded 1296 species. but had a weakness of failing to remove synonymy bias.

Forest blocks show remarkable variation in species as a percentage of total counts (Fig, 2). Kipteber leads by a significant margin of

91.6%. This is attributable to the large area comparatively (64.00% of total area). Furthermore, it has the highest altitudinal range (2400 m - 3242 m above sea level). In addition, it has diverse habitats and its proximity to the station office enhances protection. Other blocks had relatively lower numbers of *spp*. which is still commensurate with respective areas but has higher spp. densities than Kipteber. This reinforces the need for enhanced conservation efforts. Toropket the smallest by area had the lowest number of all *spp.* though with the highest spp density recorded. Of all spp. identified only 8.4% were recorded outside Kipteber. This is important because information on species location can help people interested in these species since they can narrow their searches to blocks and not the entire forest.

Various growth habits of species that was identified in the entire study area occur in proportions that conform or conflict with past surveys (Fig. 2). From the categorized eight growth forms of species, almost 50% of all species are seasonal herbs with semi-woody and woody plants comprising 38%.), This is similar to Mbuni et al. (2019), Althof (2005) and Panda et al. (2015) who recorded herbs at 54.39%, over 50% and 46% respectively. Conversely, Gurmessa et al. (2012) recorded herbs at less than 40% of the entire species composition. In general, most studies within tropical forests showed that herbs constitute 18-44% of all flora (Aigbokhan, 2014). Therefore, the high percentage of herbs in the current study implies availability of optimum conditions that supports growth, usually associated with tropical forests. Equally, these could be due to large open areas with enough light in forest areas to support fast growth which has a reflection on past management.

On epiphytes and terrestrial ferns, this study registered 34 and 49 species accounting for 4.2% and 6%, respectively of the entire species population. Mbuni et al. (2019) found 3.55% of all species as epiphytes. Nevertheless elaborate studies opine that due to the high precipitation and relative humidity, epiphytes and terrestrial ferns are usually the most frequent life forms aside from trees (Boehmer, 2011). The current results could imply that several epiphytes have not been registered (some are located far in tree crowns). Or the forest composition has been compromised by disturbance regimes not explored in this study. Despite this scenario, it should be noted that woody epiphytes in this study have been recorded under woody plants, this could affect the final percentage of epiphytes. In general these, findings together with previous local studies demonstrate that there is a decline in fern and orchid families that constitute the majority of epiphytes. This calls for further investigations whether it's due to disturbance, climate change, or otherwise.

A look at the distribution of species in different growth forms per block (Fig. 3) concerning the areas per block, gives an impression that species per growth form is roughly related to block area with very minor exceptions. This could suggest that blocks are subjected to similar management practices and disturbance regimes or those factors of growth in all blocks are similar. Again, more importantly, and as expected, large areas have more species than small ones. However, it's not clear at this point if the same growth habits are represented by species with similar requirements. Or its vegetation interaction is perturbed by human activities like encroachment. Previous land-use and forest management have been shown to influence the development of plant species, richness and evenness (Tenzin & Hasenauer, 2016). Human-induced disturbances can have a strong influence on plant species composition. In this perspective, this study supports the conclusion by Althof (2005) that high species richness is not always a suitable measure of forest quality, but the proportion of climax species typical for the Forest would form a better indicator.

The higher number of epiphytes and perennial herbs present in Kipteber demonstrates that it is comparatively better conserved than the rest of the forest. This is because vascular epiphytes and some herbs are quite sensitive to changes in their microclimatic conditions and those caused by disturbance of the forest (Fikadu et al., 2014). Such plant groups occur only in primary forest sites and are useful bioindicators that determine the degree of disturbance (Plas et al., 2018). Considering that epiphytes are an integral component of Afromontane forests they contribute considerably to biodiversity. By their adaptations to arboreal lifestyles, they increase canopy diversity, enable many animals to colonize the treetops, increase the plant biomass, water storage, and nutrient cycling. This means that some functions of the forest have slackened and weeds could be taking over the forest. This calls for measures to reverse the trend by enhancing conservation. This sensitivity makes them crucial for conservation purposes.

From the eight biogeographical affinities defined, I get the impression that disturbed, woodland and montane species are the primary occupants of the forest (Fig.3). This being a montane forest, the high presence of disturbed ecosystem affiliated species indicates activities that amount to forest disturbance. The presence of woodland species could have culminated from the impacts of climate change. In addition, it's clear from the results that larger and less disturbed forest blocks exhibit more forest edge species. The existence of such species indicates that species composition is not simple a mixture of communities. Instead, edges have their typical species (Aggemyr et al., 2018). Thus, edges are acknowledged as a separate habitat type. In the alpine zone, only 2.8% of species similar to Chaturvedi & Raghubanshi (2014**)** was registered. Therefore, from the major biogeographical affinities registered, managers should be alarmed by the impacts of climate change and disturbance.

The ten largest families comprise 399 species or 49% of all species identified (Fig 4). This leaves 406 species in 118 families. In the current study, Asteraceae, Orchidaceae and Fabaceae are the richest families respectively .This mirrors the findings of Goldblatt & Manning (2002) in cape region and (Zhou, 2017) in Kenya. More importantly, it corroborates the opinion of the Plants of the World online (POWO.science.Kew.Org). However, a few studies introduce poaceae in the list of the first three largest families (Fischer et al., 2010; 2006; Ayanaw & Dalle, 2018; Zhou et al., 2017). The conclusion of these later studies that Poaceae is richer than Orchidaceae may have been influenced by studies in woodland sites that possess more of the grass family. By knowing a family, one can tell characters of many more genera and species and may even predict the(Gastauer & Meira Neto, 2017). Therefore, knowing family will significantly reduce efforts in science, and subsequently assist conservationists and researchers.

From the available literature, several species found in the study area do not appear in previous databases on Cherangani (Table 3). The most conspicuous species in this study, were *Calceolaria tripartita* Nothoscordum bobornicum and Petunia species. reported for the first time in Cherangani, Kenya and probably East Africa (Plate 2). The genus (*Calceolaria*) formally Scrophulariaceae is now family (Calceolariaceae with 2 genera). This genus is native to Mexico with about 271 species (Christenhusz & Byng, 2016). The species was cited in Kapcherop town on the periphery of the tea plantation.

The genus Calceolaria is composed of herbs and shrubs up to 4m tall with opposite leaves and usually yellow flowers. *Calceolaria* L (1770: 286) with 23 synonyms, The species is a seasonal herb up to 22 cm tall with tripartite lobed leaves and flowers yellow Although it has always been regarded as a distinct genus, its relationships has remained unresolved until recently (Puppo, 2014).. The species is planted as ornamental but at times it is an escapee from cultivation. However, how the species reached Kenya has remained unknown raising concerns on the safety of our conserved areas from alien species some of which can be detrimental.

CONCLUSIONS AND RECOMMENDATIONS

Cherangani forest is rich with 815 vascular species is the sixth richest ecosystem in Kenya only behind Kakamega, Mt Kenya, Aberdare and Taita and Shimba forest.

On growth habits, the forest is dominated by herbs followed at a distance by trees an indication of induced disturbance. However, a few pockets of undisturbed ecosystems still exist with Ferns and Orchids.

The number of species in each biogeographical affinity appears to be related to the size of the block and indication that blocks have been previously subjected to similar management. Few areas with a high number of epiphytic ferns and orchids should be guarded jealously.

The few remaining areas of intact native forests should be prioritized for conservation regardless of their size and connectivity. If diversity is conserved within these fragments, the short-term effects of landscape-scale change may be minimized. They may then be reversed if long-term restoration initiatives can be implemented.

In addition to domestication, threatened species like Osyris, Prunus africana, and Olea africana should be mapped for enhanced protection.

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