Distribution and abundance of *Hypoestes forskaolii* (Vahl) in the exclosures of Tigray, northern Ethiopia

Haftom Gebremedhn, Girmay Darcha[1] and Kinfe Mezgebe[2]

Department of Apiculture and Sericulture, Mekelle Center, Tigray Agricultural Research Institute
haftush@yahoo.com
[1] Department of Forestry and Agroforestry, Mekelle Center, Tigray Agricultural Research Institute, P O Box 492, Mekelle, Tigray, Ethiopia
[2] Tigray Agricultural Research Institute, P.O.Box 492, Mekelle, Tigray, Ethiopia

Abstract

Establishment of exclosures to conserve biodiversity and enhance land restoration has been practiced for the past three decades in Tigray.*Hypoestes forskaolii* (Vahl) locally named as *Grbia* is the most important honeybee flora growing in these exclosures. However, empirical data and evidence on the capability and constraints of exclosures in growing the most useful honeybee plants in terms of tolerance to grass competition and tree canopy cover are lacking. Thus, the study was designed to assess *Hypoestes forskaolii* (Vahl) performance, distribution, abundance and its association with other plants in exclosures and adjacent open grazing areas of *Gergera* and *Merer* exclosures of Atsby-Wonberta and Ganta Afeshum districts, respectively. Transect method was employed to assess honey bee flora composition in exclosures and its adjacent communal open grazing land at different altitudinal positions (bottom, middle and top) of the exclosures and Agroecology (highland and midland). The collected data were analyzed using general linear model of Genstat software version 14.

The result of this assessment indicated that abundance of *H.forskaolii* was 96700/ha and 88000/ha in *Merer* and *Gergera* exclosures, respectively. Agroecology and altitudinal gradient of exclosures however had not significant effect on the abundance and distribution of *H.forskaolii*. However, the management type (exclosure and open) were significantly affected the density of*H.forskaolii*. This study concluded that exclosures with *H.forskaolii* need silvicultural practices and weeding managements to enhance its density and growth performance.

Key words: *density, ecology, honeybee*

Introduction

Plants are the food source of honeybees. Honeybee visits flowers to collect pollen and nectar for honey production and colony maintenance (Jones and Yates 1991). Ethiopia is gifted with diverse and unique flowering plants, as discussed by many authors (Admasu 1996; Fitchel and Admasu 1994; Gezahegn 2007; Gidey and Mekonen 2010) making it highly suitable for a large number of bee colonies. *Hypoestes forskaolii* (Vahl) is the most important honeybee plant for its abundant pollen and nectar in Northern Ethiopia, especially Tigray region (Haftom et al 2011). It is locally known as

Grbia (Fitchel and Admasu 1994; Haftom et al 2011; Alemtsehay 2011). According to the local beekeepers (personal communication 2015 and Haftom et al 2011), honeybees produce large quantities of light and pure white honey, which has high demand and price in the market from this plant.

Honey from Tigray region, white honey, is very popular and has high demand in the local market (UNIDO 2009). Locally, it is the most expensive (Taddele and Nejdan 2008) and often comes from specific districts in the region like Hawzien, Hagereselam, Atsby-Wonberta, Adigrat and Woukro (Taddele and Nejdan 2008). These districts are the main habitats of *H.forskaolii (Vahl),* (Haftom et al 2011; Alemtsehay 2011). Honey from this plant species and supplied by these districts are preferred by consumers because of its attractive color, pleasant taste and also gets a premium price in the local market (Taddele and Nejdan 2008).

In Tigray regional state of Ethiopia, establishment of exclosures to restore and enhance vegetation cover and honeybee flora (Nyssen et al 2007) have been practiced for the past three decades with promising outcomes (Emiru 2002 and Tefera et al 2004). Exclosures allow native vegetation to regenerate as a way to reduce soil erosion, increase rain water infiltration and provide many products and services (e.g. Emiru 2002; Mekuria et al 2007; Nyssen et al 2007; Aerts et al 2009). These positive consequences are also noticed and appreciated by the local farmers (Nyssen et al 2007). However, the local people and agricultural experts have argued also that important herbaceous honeybee flora such as *Hypoestes forskaolii* (Vahl) has been decreasing their density and performance following establishment of exclosures due to resource competition (personal communication 2015). Despite the emerging and promising socio-economic and ecological significance of exclosures in Tigray, no quantitative measurements have been carried out about the capability and constraints of exclosures in growing the most useful honeybee plants. Moreover, their distribution and abundance across exclosures and association with other plant species is not yet investigated. From an ecological and conservation point of view, assessment of biodiversity of any habitat has been regarded as one of the vital issues for careful preservation, promotion and management of honeybee plants (Emiru 2002). Hence, this study was designed to investigate species composition, distribution and performance of *H.forskaolii (Vahl)* in exclosures of eastern zone of Tigray.

Materials and methods

Study area description

The study was conducted in two agro ecology zones of Tigray region, Northern Ethiopia. From each agro-ecology one representative district was selected based on its potential to grow *H.forskaolii* and the availability of this plant. Based on this, *Atsby wonberta* and *Ganta-afeshum* districts were selected from highland and mid-highland agro ecological categories, respectively. Considering closing age relatively the same, *Merer* and *Gergera* exclosures were selected from *Ganta-afeshum* and *Atsbi wenberta* districts respectively.

Study design

This study was conducted in two exclosures and one open grazing land for comparison which had similar conditions before the establishment of the exclosures. The reason we took only one grazing land from *Ganta-afeshum* district was due to lack of open grazing communal area in *Atsbi wenberta*. The study was conducted in highland and mid-highland agro-ecological zones of eastern Tigray during flowering period of the plant i.e. December, 2014. The total number of transects and plots were determined based on the total size of the selected exclosures. The total number of transects was determined by dividing the total horizontal size of the exclosure to 250m, which is the distance between transects. Plant composition and density comparison was done in three altitudinal gradients (bottom, middle and top of the exclosure) and with a total of thirty six plots.

Data were collected based on transect lines perpendicular to the contours. A total of four line transects with an average length of 400m were laid at a distance of 250m between transects. To avoid the effect of disturbances the first and last line transects were laid at a distance of 100m from the edges. On each line transect three sample plots were laid at every 70m elevation gradient starting from the bottom to the top of the mountain. The size of the plots was varied with plant type. For this purpose 10m by 10m for tree, 4m by 4m for shrub and 1m by 1m for herbs were used to investigate the type and number of plants per plot.

In each plot, all woody tree species with a diameter at breast height/DBH/ greater than 5cm and height greater than 3m were considered as trees. Plants with a DBH less than 5cm and DBH greater than 2cm and height of 0.5m to 3m were classified to shrub. Similarly, plants were categorized to seedlings or herbs with DBH less than 2cm and height less than 0.5m (Mengustu 2005). Diameters and heights were measured using diameter tape and clinometers, respectively. Within each sample plot, the number of individual species was determined by direct counting. The woody plant species found at each plots were identified on the field based on researcher experience supported by plant knowledge of local elders and published materials such as useful trees and shrubs of Ethiopia (Azene et al 1993).

Data analysis

Species diversity

A species diversity index was analyzed using software PAST (Hammer et al 2001). The total number of species in a community was referred to as species richness while species evenness explains as to how species abundance was distributed among species. Diversity has emerged as the most widely used criterion to assess the conservation potential and ecological value of a site (Magurran 1988).

Shannon Wiener's diversity index

Shannon diversity index accounts for both the diversity and evenness of the species present in a community and computed using (Eq.1). This index takes into consideration of species composition and evenness within the given land or community.

Where: H = species diversity index; ln = natural logarithm

Pi = n/N is the proportion of individuals found in the i^{th} species (ranges 0 to 1); and

n = number of individuals of a given species; N = total number of individuals found (Shannon and Wiener 1949).

Species composition

Plant species abundance, frequency, relative density, relative frequency was determined using the following formulas.

Species density was determined by counting the number of individuals in the sample plots and converting the count into hectare basis.

Abundance, Canopy cover, area coverage and height of ***H.forskaolii***

Performance of *H.forskaolii* across the different elevations and agro ecologies was determined in terms of canopy cover, height and coverage of the plants per a given area. The area coverage of *H.forskaolii* was determined by estimating the total area covered by the plants of the total area of the quadrant in percent. The canopy cover was calculated by using the formula

$$C.C = (D_1 + D_2)/2 ,$$

Where D_1 is the diameter of the plant towards the North- South and D_2 is the diameter of the plant towards West-East direction and **C.C** represents the canopy cover of the plant in cm. So the canopy cover of the plant was expressed in terms of the average diameter in cm. The height of the plants was measured from the ground to the tip of the longest branch with the help of a measuring tape.

Data analysis

The collected data related to density, abundance, plant height and canopy cover were analyzed using general linear model. During data analysis agro-ecology and level of elevation gradient were considered as factors. The least significant difference test was calculated to identify significant differences among the treatments (across agro-ecology and altitudinal gradients) and t-test was conducted for comparing open and closed areas using the statistical program GENSTAT Version 14.

Results and discussion

Effect of agro-ecology and altitudinal gradient on plant density

The location had a significant effect on tree and shrub density/ha (Table 1). *Merer* exclosure had higher tree density (119) than*Gergera* exclosure (17). This might be due to the reason that *Merer* exclosure practiced enrichment planting as well as good protection from cutting of remnant indigenous tree species than that of *Gergera* exclosure. Related to shrub abundance, *Gergera* exclosure (1311) had higher shrubs density/ha than *Merer* exclosure (598). Altitudinal gradient of exclosure however, had not significant effect on the density of tree, shrub and herb species. This indicates that the important honeybee plants like *H.forskaolii* can grow in any position of the altitudinal gradient. Related to coverage of tree species, *Merer* exclosure (14.4%) had higher coverage than *Gergera* exclosure (1.4).

The highest density of herb species in general and *H.forskaolii* in particular in *Gergera* exclosure might be due to the lowest density of tree species in *Merer* exclosure (Table 1). This shows that less availability of tree species makes favorable condition to grow more herbaceous species like the important honeybee plant *H.forskaolii* in the study site. This finding is supported by many authors (e.g. David and Don 2003; Andrew 2005) concluded that areas with less tree canopy cover can enhance more diverse herbaceous species than areas with many tree species and large canopy coverage.

Table 1. Effect of location and altitudinal gradient on plant density in exclosure

Factors		Tree	Shrub	Herb	*H. forskaolii*
Altitude	Bottom	62	882	11500	87500
	Mid	88	882	12125	62500
	Top	53	857	13375	80000
	P value	0.52	0.99	0.95	0.8
Location	*Merer*	119	598	11212	65000
	Gergera	17	1311	13704	88333
	P value	<0.0001	0.002	0.60	0.46

Relative frequency and density of tree species in exclosures

In both exclosures a total of 6 tree species was recorded. Among the tree species *Eucalyptus camaldulnesis* had the highest relative frequency and density in both watersheds. Next to this plant *Juniperus procera* and *Dodonaea anguistifolia* had the highest relative frequency and density in *Merer* and *Gergera* exclosures, respectively (Table 2). Compared with the study conducted by Girmay et al (2015) in Serako district, Northern Ethiopia, this study area had lower woody species. This species difference might be due to difference in climate, age of exclosure, site and management conditions. In *Serako* exclosure *Dodonaea anguistifolia* had the highest density (Girmay et al 2015) which is similar with this study.

Table 2. Frequency and density of each tree species in exclosures

Location	Vernacular name	Scientific name	Frequency in %	Relative frequency	Den

Merer	*Bahrzaf*	*Eucalyptus camaldulnesis*	75.0	34.6	2
	Tshdi	*Juniperus procera*	58.3	26.9	1
	Atkaro		8.3	3.8	4
	Chaa	*Acacia lehay*	16.7	7.7	8
Gergera	*Bahrzaf*	*Euccalyptus camaldulenisis*	25.0	11.5	3
	Tahses	*Dodonaea anguistifolia*	16.7	7.7	1
	Akacha	*Acacia saligna*	8.3	3.8	8
	Awlie	*Olea europiana- Africana*	8.3	3.8	8

Relative frequency and density of herb species in exclosures

A total of 12 and 9 herb species were also documented in Merer and Gergera exclosures, respectively (Table 3). Among the herb species*H.forskaolii* had the highest relative frequency in both *Merer* (31.4) and *Gergera* (31.6) exclosures. It had also the highest abundance in both exclosures compared to other herb species (Table 4). The density of *H.forskaolii* was 88333/ha and 96666/ha in Merer and Gergera exclosures, respectively. However, location and altitudinal gradient had not a significant effect on the abundance *H.forskaolii*. This clearly indicated that the plant can grow in association to the other plants across locations, altitudinal gradient and with the existing canopy cover without any significant problem.

Among the herb species, *H.forskaolii* (91.7%) the most frequent honeybee flora in *Merer* exclosure followed by *Carduus camaecephalus* and *Rumex nepalensls* (16.7%) (Table3). In this exclosure, the frequency of some of the economically important species such as *Opuntia ficus-indica* and *Aloe berhana* were 8.3% of the total sample, which were the least frequent species. Among the herb species and as demonstrated in Table 4,*H.forskaolii* had the highest frequency (100%) followed by*Carduus camaecephalus* (41.7%) *and B.grandiflorum* (25%) in *Gergera* exclosure. Different authors (Fichtl and Admassu 1994, Haftom et al 2011) have confirmed the abundance and wide distribution of white honey bearing species like *H.forskaolii* creating a good opportunity to plan for bulk production in the Eastern zone of Tigray.

Table 3. Frequency and density of each herb species in exclosures of *Merer* exclosure

Vernacular name	Scientific name	Frequency in %	Relative frequency
Beles	*Opuntia ficus-indica*	8.3	2.9
Chena abatea		8.3	2.9
Dandear	*Carduus camaecephalus*	16.7	5.7
Ere	*Aloe berhana*	8.3	2.9
Grbia	*Hypoestes forskaolii*	91.7	31.4
Machiqae		8.3	2.9
Muchelea	*Achyranthesaspera*	16.7	5.7
Shembaeta	*Rumex Nepalensls*	16.7	5.7
Shumbue		8.3	2.9
Tebeb	*Becium grandiflorum*	33.3	11.4
Tsaeda qotsli	*Phagnalon abyssinicum*	8.3	2.9

Table 4. Frequency and density of each herb species in exclosures of *Gergera* exclosure

Vernacular name	Scientific name	Frequency in %	Relative frequency
Grbia	*Hypoestes forskaolii*	100	31.6

Chena abatea		8.3	2.6
Dandear	*Carduus camaecephalus*	41.7	13.2
Tebeb	*Becium grandiflorum*	25.0	7.9
Sasa	*Otostegiatomentosa*	8.3	2.6
Eungle	*Solanum incanum*	8.3	2.6
Shwakerni	*Leucas abyssinica*	16.7	5.3
Beles	*Opuntia ficus-indica*	8.3	2.6
Hohot	*Rumex Vernosus*	8.3	2.6

Effect of altitude and location on canopy cover, coverage and plant height of *H.forskaolii*

The location had not a significant effect on plant height and canopy cover of *H.forskaolii*. The largest height, canopy cover and area coverage of *H.forskaolii* were recorded at the middle elevation of *Gergera* and *Merer* exclosures (Table 5).

Table 5. Effect of altitude and location on height, canopy cover and plant coverage of *H.forskaolii* in exclos

Factors	Altitude gradient	Height (cm)	Canopy cover (cm)	Cove
Altitude	Bottom	29.6	19.1	28
	Mid	30.8	24.5	37
	Top	27.3	19.8	30
	P value	0.8	0.4	0

Location	*Merer*	31.6	23.1	4[illegible]
	Gergera	26.9	19.1	2[illegible]
	P value	0.3	0.2	0[illegible]
Location*Altitude	*Merer* *Bottom	29.5	17.9	38[illegible]
	Merer *Mid	35.7	29.7	58[illegible]
	Merer *Top	29.6	21.9	4[illegible]
	Gergera *Bottom	29.8	20.3	18[illegible]
	Gergera *Mid	25.9	19.3	17[illegible]
	Gergera *Top	25.0	17.8	30[illegible]
	P value	0.7	0.3	0[illegible]

Richness, Dominance (D), Evenness and Density of honeybee plant species across different altitude and locations

The location had a significant effect on richness, dominance, evenness and diversity of tree species (Table 6). *Merer* exclosure had higher tree species diversity (0.4) and richness (1.5) than species diversity (0.1) and richness (0.5) of *Gergera* exclosure. *Merer* exclosure had also higher tree species evenness (1) than *Gergera* exclosure (0.4). This indicates that in *Gergera* exclosure the density of tree species was dominated by single species.

The higher abundance of tree species was also found in *Merer* exclosure (0.8) than *Gergera* exclosure (0.4) and as demonstrated in Table 6, the dominate tree species was *Eucalyptus camaldulnesis* . However location had not significant effect on richness, dominance, evenness and diversity of shrub and herb species.

Table 6. Dominance, evenness and diversity of honeybee plant species across different altitude and loca

Factors	Richness	Dominance D	Evenness

		T	S	H	T	S	H	T	S	H
Altitude	Bottom	0.9	4.4	2.3	0.7	0.4	0.6	0.8	0.8	0.7
	Mid	1.3	5.8	2.5	0.6	0.4	0.7	0.9	0.7	0.9
	Top	0.8	4.5	2.5	0.4	0.4	0.7	0.5	0.7	0.9
	P value	0.3	0.2	0.9	0.3	0.8	0.7	0.1	0.2	0.2
Location	*Merer*	1.5	4.9	2.4	0.8	0.4	0.6	1	0.7	0.8
	Gergera	0.5	4.8	2.4	0.4	0.4	0.7	0.4	0.8	0.9
	P value	0.001	0.9	1.0	0.001	0.5	0.4	0.001	0.8	0.6

Where T=tree, S=shrub and H=herb

Species richness, evenness and diversity were higher in middle position of the altitudinal gradient as compared to bottom and top position. However, altitude had not significant effect on species richness, evenness and diversity (P>0.05, Table 6). The higher value in the middle altitudinal gradient might be due to the safe position of the exclosure from anthropogenic interference. According to Issango (2004) woody species with high resistance to anthropogenic disturbance and those with efficient regeneration capacity have relatively high chance of remaining the dominant and important species in an area.

Frequency and density of herb species under open areas

In an open area, *H.forskaolii* had the highest frequency (91.7) and density (165833/ha) compared to other herb species (Table 7). As demonstrated in the above table (Table 4) *H.forskaolii* had similar frequency compared to the frequency of the plant in exclosures (91.7). Beside to this, ***Grbia*** (*H.forskaolii)* had higher density in open area (165833/ha) than in exclosures (96666/ha). This indicates that *H.forskaolii* had higher density in open areas than exclosures. This might be due to the following reasons: the plant might be less affected by human due to low cultural and social values (Haftom et al 2012); has a low animal preference for feed and the plant may have also weak resource competition with other herbaceous species like grass and weeds in the exclosures. This study is in line with other previous watershed management related impact studies (e.g. Negussie et al 2008; Raf et al 2009) reported that high plant seedling mortality is often related to high browsing pressure for palatable species by herbivores.

Table 7. frequency and density of herbs under open areas

Vernacular name	Scientific name	Frequency	Frequency %	Re.frequ
Beles	*Opuntia ficus-indica*	2	16.7	8.70
Chena abatea		2	16.7	8.7
Dandear	*Carduus camaecephalus*	1	8.3	4.4
Engule		1	8.3	4.4
Grbia	*Hypoestes forskaolii*	11	91.7	47.8
Chaa	*Acacia Lehay*	1	8.3	4.4
Agol		1	8.3	4.4
Shembaeta	*Rumex Nepalensls*	1	8.3	4.4
Shumbue		2	16.7	8.7
Ere	*Aloe berhana*	1	8.3	4.4
Total			192	100

Frequency and density of tree species under open areas

In open areas *Acacia lehay* had the highest frequency (6) and density (200/ha) followed by *Eucalyptus camaldulnesis* (Table 8) while in exclosures *Eucalyptus camaldulnesis* followed by

Juniperus procera had the highest frequency and density (Table 2).

Table 8. Relative frequency and density of Trees under open areas

Vernacular name	Scientific name	Frecuency	Frequency %	Re
Bahrzaf	*Euccalyptus Camaldulenisis*	5	41.7	3
Chaa	*Acacia Lehay*	6	50	4
Tshdi	*Juniperus procera*	2	16.7	1
Total			108	1

Richness, dominance (D), evenness and density of honeybee plant species in open and exclosures

The land use had not significant effect on richness, dominance, evenness and diversity of herb species (Table 9 and Table 10). The dominance of shrubs was 0.4 and 0.4 in exclosures and open areas, respectively. Herbs in exclosures and open areas had a dominance of 0.6Â±0.1 and 0.7Â±0.1, respectively. As demonstrated in table 9 and 10 we did not detect differences among land use types (P>0.05) in shrub and herb species diversity (H), suggesting that interference of human and domestic grazing animals in open areas of the study area is minimal. For instance, Raf et al (2009) discussed that high plant seedling mortality is often related to high browsing pressure by large or small herbivores.

Table 9. Dominance, evenness, richness and diversity of shrub species in closed and open areas

Land use	Dominance (D)	Evenness	Richness	Species diversity (H)
Enclosure	0.4Â±0.1	0.7Â±0.1	4.9Â±0.5	1.2Â±0.1
Open	0.4Â±0.1	0.6Â±0.1	4.7Â±0.6	1.1Â±0.1

t-value	0.5	1.2	0.3	0.6
P value	0.6	0.2	0.8	0.6
DF	22	22	22	22

Table 10. Dominance, evenness, richness and diversity of herb species in closed and open areas

Land use	Dominance (D)	Evenness	Richness	Species diversity (H)
Enclosures	0.6Â±0.1	0.8Â±0.1	2.4Â±0.5	0.6Â±0.2
Open	0.7Â±0.1	0.7Â±0.1	2.0Â±0.4	0.3Â±0.1
t-value	-1.4	1	0.7	1.5
P value	0.2	0.3	0.5	0.1
DF	22	22	22	22

Density, height, cover and canopy cover of *H.forskaolii* under open areas and exclosures

Land use had a significant effect on the density of *H.forskaolii* (Table 11). Similarly, *H.forskaolii* also had higher density in open areas (252111Â±86.4) than exclosures (129487Â±9.6). However, land use had not significant effect on height, cover and coverage of *H.forskaolii*. In exclosures and open areas, *H.forskaolii* had a height of 34.9Â±2.1cm and 26.6Â±2.1cm, respectively. This indicates that *H.forskaolii* had similar performance in terms of plant height and canopy cover in open areas and exclosures.

Table 11. Density, height, cover and canopy cover of *H.forskaolii* under open and closed areas

	Density	Height (cm)	Cover (%)	Canopy cover (cm)

Land use	x Â±se	x Â±se	x Â±se	x Â±se
Enclosures	129487Â±9.6	34.9Â±2.1	47.5Â±10.1	23.8Â±3.3
Open	252111Â±86.4	26.6Â±2.1	46.4Â±9.6	19.8Â± 2.8
T-value	-1290	2.8	0.1	0.9
P value	< 0.001	0.01	0.9	0.4
DF	19	19	19	19

DF: degree of freedom

Conclusions

- The important honey bee flora, *H.forskaolii* was well distributed in the altitudinal gradient of both exclosure of the study area.

- The study concludes *Merer* exclosure had higher tree species density, diversity and richness than species density, diversity and richness of *Gergera* exclosure. *H.forskaolii* had higher frequency and density in open areas compared to exclosures.

- Since the density, frequency and growth performance of this important honey bee plant, *H.forskaolii,* is higher in open areas, it is advisable to demonstrate appropriate silvicultural management practices in exclosures like canopy openness and weeding of other herbaceous species for sustainable management of bee colonies and good honey harvest.

Acknowledgements

We thank Niguse Hagazi for is valuable comments as well as Mehari Kebede for his special support during data collection. The research was supported financially by Tigray Agricultural Research Institute, Mekelle Agricultural Research Center.

Reference

Abeje E, Demel T and Hulten H 2005 The socio-economic importance and status of populations of *Boswellia papyrifera* (Del.) Hochst in Northern Ethiopia: The case of north Gondar zone. *Forests Trees and Livelihoods*, **15**:55-74.

Admasu A 1996 Preliminary investigation on the taxonomy of Ethiopian honey bee flora. April 18-19, 1996. Proceedings of the 4th annual conference of the Ethiopian society of animal production (ESAP): held in Addis Ababa, Ethiopia. pp181-186.

Akratanakul P 1990 Beekeeping in Asia. FAO (Food and Agriculture Organisation of the United Nations), Agricultural Services. Bulletin 68/4. Rome, Italy.

Alemtsehay T, Yosef M and Gebremedhin W 2011 Seasonal availability of common bee flora in relation to land use and colony performance in Gergera watershed Atsbi Wembwrta district eastern zone of Tigray, Ethiopia, M.Sc. Thesis.Wondo genet college of forestry and natural resources, school of graduate studies, Hawassa university wondo genet, Ethiopia.

Andrew S 2005 Effects of changes in canopy cover on understory vegetation in the long island pine barrens, Upton New York.

Azene B 2007 Useful trees of Ethiopia: identification, propagation and management in 17 agroecological zones. Nairobi: RELMA in ICRAF Project, 552.

Bista S and Shivakoti P G 2001 Honeybee flora at KabreDolakha District, Nepal. Journal of Napal Agricultural research. **4** & **5**: 16-25.

David L and Don G 2003 Rehabilitation and Restoration of Degraded Forests.IUCN, Gland, Switzerland and Cambridge, UK and WWF, Gland, Switzerland. x +110 pp.

Fitchel R and Admasu A 1994 Honeybee flora of Ethiopia. The national herbarium, Addis Ababa university, Deutscher Entwicklungsdienst (DED). Margrafverlag, Germany.

Gezahegn T 2007 Adaptation trial of honey plants: adaptability trials of temperate honey plants in Ethiopia. Ethiopian Beekeepers Association newsletter Vol.5, NO.1, pp 16-17.

Gidey Y and MekonenT 2010 Participatory technology and constraints assessment to improve the livelihood of beekeepers in Tigray region, northern Ethiopia. CNCS Mekelle University. Volume 2 (**1**): 76-92. Retrieved, from http://www.ajol.info/index.php/mejs/article/view/49654

Girmay D, Emiru B and Nigussie A 2015 Woody species diversity in *Oxytenanthera abyssinica* based homestead Agroforestry systems in Serako, Northern Ethiopia Vol 5(9), Journal of Natural Sciences Research. Retrieved, from http://www.iiste.org/Journals/index.php/JNSR/article/download/22390/23189

Haftom G and Tesfay B 2012 Effect of pruning on vegetative and flowering patterns of *Becium grandiflorum* . Livestock Research for Rural Development. *Volume* ***24***, Article # 175. Retrieved, from http://www.lrrd.org/lrrd24/10/haft24175.htm

Haftom G and Yaynishet T 2012 Identification and evaluation propagation techniques of *Hypoestes forskaolii* (Grbia) as bee fodder for smallholder farmers. Livestock Research for Rural Development. Volume 24, Article #170. Retrieved , from http://www.lrrd.org/lrrd24/9/gbia24169.htm

Haftom G, Zelealem T, Girmay M and Awet E 2011 Honeybee flora seasonal availability and honeybee seasonal activity and managemental interaction in Debrekidan and Begasheka watershed, Tigray, Ethiopia. Proceedings of the workshop on accomplishments of the operational research project (2008- 2011). April 29-30, 2011, Mekelle, Ethiopia, pp. 72-84"

Issango O J 2004 Impact of fire on the woody vegetation in Mgori forest reserve Singida, Tanzania. MSc. Thesis, Addis Ababa University

Jones D and Yates B D 1991 Beekeeping study notes. 2nd Edition. Bee Books New and Old Tapping Wall Farm, Burrowbridge, Bridgwater TA7 ORY, Somerset, U.K.

Kent M and Coker P 1994 Vegetation Description and Analysis. A Practical Approach. John Wiley & Sons Ltd. ISBN 0471948101, England.

Negussie A, Aerts R, Gebrehiwot K and Muys B 2008 Seedling mortality causes recruitment limitation of Boswellia papyrifera in northern Ethiopia. J. Arid. Environ. **72**: 378–383.

Nyssen J, Descheemaeker K, Nigussie H, Mitiku H, Deckers J and Poesen J (eds) 2007 Lessons learnt from 10 years research on soil erosion and soil and water conservation in Tigray, Tigray Livelihood papers no.7, Mekelle: Zala-Daget Project, Mekelle University, K.U.Leuven, Relief Society of Tigray, Africamuseum and Tigray Bureau of Agriculture and Rural Development, **53** p. ISBN 978-90-8826-027-8.

Raf A, Jan N and Mitku H 2009 On the difference between “exclosures” and “enclosures” in…, Journal of Arid Environments, doi:10.1016/j.jaridenv.2009.01.006

Received 8 December 2016; Accepted 4 April 2017; Published 1 August 2017

Go to top