Floral establishment of major honey plants in north western zone of Tigray,Ethiopia

Haftom Kebede[a] and Samuel Gebrechirstos[b]

Abstract:

Identification of flowering calendar of honey plants is critical in improving yields of hive products. This study was carried out to survey plants foraged by honeybees (Apis mellifera L.) and to identify them in one wereda (Tahtay koraro) of North Western zone of Tigray. Species identification with their flowering and characterization was made using direct observation, questionnaires, interview and focus group discussion. The result was analyzed using descriptive statistics. A total of 51 species belonging to 37 families with 16 major species, 13 secondary and 8 minor plants foraged by honey bees was identified. The species Cordia africana, Bidens species, Trifolium species, Carthamus tinctoriu, Parkinsonia aculeate, Zizipus Spina-christi, Carrisa edulis, Mimusops kummel, Diosypros mespiliformis, Acacia sieberiana,Terminalia glaucesIcens, Grewia ferruginea, Opuntia ficus-indica, Syzygium guineense, Carica papaya L.and Buddleja polystachya were classified as major honey plants. The months ranging from December to June were identified as scarcity period. Majority of the flowering plants such as Cordia africana, Dodonaea angustifolia,Pterolobium stellatum, Carica papaya L.,Citrus sinensis pers, Psidium guajava, Zea mays, Otostegia integrifolia, Bidens species, Trifolium species, Bidens pachyloma, Carthamus tinctorius, Guizotia abyssinica, Brassica napus, Parkinsonia aculeate, Zizipus Spina-christi, Jasminum floriban, Cirsium vulgare, Capparis erythrocarpus, Acacia pilispina, Capsicum annum, Calpurnia aurea, Persea Americana, Mimusops kummel, Agave sisalana, Datura stramonium, Anogeissus leiocarpus, Vicia faba, Ficus vasta and Diosypros mespiliformis bloom between the months of August and November. Majority of the honey bee plant species (66.67%) propagated through seedling followed by wilding (15%). The source of bees, in order of importance, was from green vegetation, market sites and splitting. Therefore, Training on seasonal management of honey bees through supplementation of feeds during dearth periods, pollen analysis, bee keeping development integrated with crop cultivation and natural resource conservation is recommended.

Key Words
Flowering season, Honey bees, Seasonal management, Splitting, Tigray

1. Introduction

Honey yield and its byproduct depend on availability of floral resources [15]. Bees utilize particular species of plants for a limited period of time due to seasonal blooming. There are also both quantitative and qualitative differences among flowering plant species with regards to nectar and pollen production. Some supply both nectar and pollen abundantly during flowering and others provide nectar or pollen for brood rearing [17]. Thus, beekeepers must know the time and duration of blooming season of major honey plant, environmental factors hampering honey yield and carrying capacity of the area, i.e., the number of colonies that can be put for maximum production [14].

A forager or worker bee may appear to prefer nectar of one flower species to another. This is due to its advantage to visit flowers producing greater quantities of nectar with higher concentration of sugar. If high quality of nectar is available, a forager bee of *Apis melllifera* can carry as much as 80% of their body weight [8]. This trigger for identification of highly preferable plant species using direct field observations of foraging honeybees on flowers, analysis of bee plants, pollen loads and melissopalynological analysis of honey sample [2].

Assembling a floral calendar for a specific area is time consuming. It requires complete observation of the seasonal changes in the vegetation patterns and or agroecosystem of the area, the foraging behavior of the bees, and the manner in which the honeybee colonies interact with their floral environment [12]. The accuracy of a floral calendar and hence its practical value depend solely on the careful recording of the beginning and end of the flowering season of the plants and how they affect the bees. The preparation of an accurate, detailed calendar therefore often acquires several years of repeated recording refinement of the information obtained [7].

Shire Indasilassie is among land-degraded zones of Tigray. It is characterized by subsistence farming households raising predominantly cereal and vegetable crops for local consumption and sale. Crop production in the region has failed to keep pace with population growth due to recurrent droughts and environmental degradation. There are about two zones of climate, "Kolla" and "Woina Dega". In the "Kolla" or hot zone plants Acacia, Albizza, Combretum, Citrus, Commiphora, Eucalyptus and Croton are predominantly grown while the "Woina Dega" or cool-warm is characterized by predominant plants of Acacia, Eukalyptus, Citrus, Combretum, croton, Guizotia, Trifolium, Olea and Veronica [9].

The economy of rural area of North Western Tigray is highly dependent on agricultural with small holder cultivation of cereals and pulses that mainly characterized by mixed with livestock rearing. The average landholding is about 0.5 ha per household which is too small to support daily livelihood. Therefore, there is a need to search for other alternative to insure food security in the area. Beekeeping is among the opportunities as it does not much require fertile land, large area and greater investment. Every member of the household can easily practiced bee farming. Besides these, beekeeping does not compete with other branches of agriculture for resources because bees collect pollen and nectar from wild and cultivated plants to make honey and such resources would be

important if honey bee hive colonies are established to forage on them [13].

Since modern beekeeping is relatively new practice in Ethiopia, compilation of economic bee forages and identification of areas suitable for beekeeping are still far from complete. Bees will produce more honey and consume less if they can find natural food. Calendar of flowering plants that have good nectar and pollen sources is a first step towards increasing honey yields. The flowering sequence of honey plants can be anticipated and so hives can be moved to exploit nectar flow. Plants yielding nectar or pollen through out the year can be identified and grown to over come dearth periods.

As land holding is not sufficient for realizing food security in the area; developing technologies such as proper beekeeping would play an important role in income generation. In this case, identification of important honey bee plants in the development of bee keeping has positive impact. This in turn requires proper identification of honey bee plants and establishment of floral calendar. This study is conducted to contribute to the development of beekeeping and thereby play significant role towards overall improvement in food security.

The objective of this study were: (a) To assess plants (shrubs, herbs, weeds and trees) foraged by honeybees and establish floral calendar of the plants in the study area; (b) To identify the varieties of the plants foraged by honeybees; (c) To document their sequence of flowering; (d) To identify the main flowering and dry seasons and plants utilized by bees during the respective seasons

2. Materials and methods

The study was carried out in north western zone, Tigray region Northern Ethiopia located at an altitude of between 1200-1800 masl. Shire Indasilassie is the administrative center of this zone. It is located at the northern tip of Ethiopia. It is 1087 kilometers away from Addis Ababa. Northwestern Tigray zone has seven woredas: Medebay Zana, Tahtay Koraro, Shire Indasilassie, Asgede Tsimbla, Tselemti, Laelay Adyabo and Tahtay Koraro. From these, Tahtay Koraro were selected for further analysis,. Tahtay Koraro is located in 14^0 6′ north latitude and 38^0 17′ east longitude. The area was selected because of the presence of natural vegetation, climate and bee hive population. The people's livelihood is entirely dependent on agriculture, of which beekeeping has its own important share in supporting food security and cash income earnings [5].

The soil type of the woreda is of sand-silt, silt-clay and clay. But this resources (i.e soil) has been depleted by many centuries continous cultivation. The study area is mainly covered by sandstone, Tertiary volcanics and unconsolidated sediments. The sandstone consists of intercalations of sandstone and siliceous mudstone with thin lateritic cover, and is correlated with the Adigrat Sandstone [18].

The climate is generally sub-tropical with an extended dry period of nine to ten months and a maximum effective rainy season of 50 to 60 days. The rainfall pattern is predominantly uni-modal (June to early September).The rain fall of Shire Indasellasie gets in summer season 700-1135 mm (877.6 mm), the temperature ranges 18-34.6°C. Livestock population of the woreda has a total head of 116092 of cattle, 42567 sheep, 10577 of goats, 8799 of donkeys and horse, 95 of mules, 428 of camel, 14832 of chickens and 9714 honey bee colonies. The area was covered by different trees, shrubs, herbs and grasses [20].

A general survey of the area and listing of the flowering plants was carriedout for a period of six months from October to March. The bee forage field observations was made on different kinds of plants. From the study area, plant samples were collected with necessary botanical features like leaves, flowers and portion of the stem. The plants were pressed using plant press and identified at Aksum University.

Information about honeybee plants was collected from 106 local beekeeping farmers, 6 Woreda honeybeeexpert, and 8 Kebele honeybees' development agents using prestructured questionnaire. The farmers were selected randomly among beekeepers. The expert and development agents were responsible for the development of beekeeping. The plants were categorized from the information obtained by respondents during interview and focus group discussions. The purpose of asking respondents were to obtain information about honey plants expected to be found in the study area.

A two stage sampling was followed by first selecting peasant associations(PAs) and then sample households within the described woreda. In the first stage, four kebeles within the study area where majority of honey plants with common practice of bee farming were selected purposively. Before selecting household heads, the sampling frame was stratified into traditional and modern beekeepers. The stratum of modern hive user consists of households who own, rented/shared in/out or gifted in modern hive for direct utilization. The second stratum referred to hereafter as traditional hive-users was composed of households who were involved in rearing traditional hives. In the second stage, a total of 106 households, that consisting of 53 modern hive users and 53 traditional hive users were selected from the identified list using simple random sampling technique.

Focus group discussion was also used to fill any emerging gaps in the interview and acquire adequate information about the different types of bee flowers and their flowering season. Plants of major, secondary and minor sources in nectar and pollen were identified based on the view of majority during discussion session.

The bee flora of the area was identified through direct observation and published reports. Plants were identified through observing the honey bee while foraging. If a bee thrusts its proboscis in to the interior of the flower basin, the

plant was taken as a source of nectar. The availability of pollen, on the other hand, was determined by observing bees collecting pollen and carrying it in loads on their hind legs. The status of the material, whether major or minor, was determined by the intensity of bee visits. The occurrence of the plant species was also determined by the density of the plant (number of plants/m^2 for herbaceous plants and number of plants/ha for trees and shrubs. Published reports were employed for those plants which were not observed while foraged by honey bees. The plants were identified through collecting (the whole plant for herbs and a flowering branch for shrubs and trees). The collected plants were pressed, identified and then compared to the published reports.

Descriptive statistics (mean, frequency, percentage and standard deviation) was used to summarize datas obtained from primary and secondary sources. Secondary sources were obtained from Agricultural office and research center working around the study area.

3. Results and Discussion

3.1. *Source of income*

From the total respondents interviewed, about 79.24% indicated crop cultivation as main source of income followed by bee keeping (15.1%). Other means of income, in order of importance, as prioritized by the respondents include irrigation, cattle farming, poultry farming and rearing of goats (Table 1).

Table 1. Source of income as prioritized by respondents of T/koraro

Source of income	Priority (%)			
	1st	2nd	3rd	4th
Crop cultivation	42 (79.24)	8 (15.1)	3 (5.66)	-
Bee keeping	8 (15.1)	30 (56.6)	4 (7.55)	11 (20.75)
Irrigation	3 (15.8)	9 (47.4)	7 (36.8)	-
Cattle farming	-	6 (35.3)	11 (64.7)	-
Poultry farming	-	1 (12.5)	7 (87.5)	-
Goat farming	-	-	12 (60)	8 (40)
Trade	-	-	7 (88.9)	1 (11.1)

*Figures in parenthesis indicate percentage of respondents

3.2. *Source of bee keeping*

The key source of honey bees reared in Tahtay Koraro came from green vegetation residing there either naturally or absconded from nearby around homesteads (46.42%). The second source was from market sites (32.15%) and followed by home raised through splitting (29%).

3.3. *Common flowering plants*

Various economically important flowering plants that encompass crops, shrubs and trees were available along various locations within the four tabias (PAs) of Tahtay koraro.

3.4. *Types of honey bee flora with their abundance*

3.5. *Types of the honey bee flora*

Based on the survey result obtained from the two weredas of North Western zone of Tigray, a total of 51 flowering plant species which classified under 34 families were identified. From the total listed flora types 26 were identified as trees followed by shrubs (13). Others include herbs (7), crops and spices (4) and flowering weeds (2). The proportion is in agreement with findings of Haftom et al., (2013) which studied in Begashaka and Debrekidan watersheds in Tigray [11]. The result is also similar with finding of Dukku (2013) in Sudan Savanna zone of northeastern Nigeria [22]. However, the finding deviates from the study of Alemtsehay Teklay (2011) and Debissa (2006) which ranked herbs as major sources followed by trees and shrubs [3], [6]. The deviation may be associated with the change in geographical location, soil type and climatic situation.

3.6. *Source and season of flowering*

The floral chart developed for selected species indicated that, in the months of August up to November, comparatively ambient flowers were available in the area (Figure 1). Majority of the flowering plants such as *Cordia africana, Dodonaea angustifolia,Pterolobium stellatum, Carica papaya L.Citrus sinensis pers, Psidium guajava, Zea mays, Otostegia integrifolia,* Bidens species, Trifolium species, *Bidens pachyloma, Carthamus tinctorius, Guizotia abyssinica, Brassica napus, Parkinsonia aculeate, Zizipus Spina-christi, Jasminum floriban, Cirsium vulgare, Capparis erythrocarpus, Acacia pilispina, Capsicum annum, Calpurnia aurea, Persea Americana, Mimusops kummel, Agave sisalana, Datura stramonium, Anogeissus leiocarpus, Vicia faba, Ficus vasta and Diosypros mespiliformis* bloom between the months of August and November (Fig 1).

According to respondents, the flowering period of *Eucalyptus camaldulensis* is all year round. This is in agreement with findings of Gebre (2009), Alemtsehay Teklay (2011) and Assemu Tesfa *et al*., 2013 [10], [3], [4]. The finding of Tolera

Kumsa and Dejene Takele (2014), on the other hand, deviates from current which reported that the blooming period of *Eucalyptus camaldulensis* fall between the months of April to June [21]. Abebe Jenberie *et al.,* 2014 also reported that the blooming period of *Eucalyptus camaldulensis* is in May on his study in north east areas of Amhara region [1]. Despite the above variation, the year round blooming behavior of eucalyptus species in our study area has significant contribution for improving productivity as the bees used it for alternative feed during forage scarcity**.** As to the respondents, blooming was associated with availability of seasonal rainfall. Even, the erratic rainfall coming during winter seasons has its own contribution for availability of some flowering plants such as Trifolium.

Although there is shortage of honey bee floras throughout the year, the months of December to June were identified as dearth period in which there is no rainfall and the temperature is dry and hot in the study area. During this period, few species with comparatively localized in certain area bloom. The species include *Eucalyptus camaldulensis, Rhamnus Prinoides L., Carica papaya L., Mangifera indica L, Acacia albida, Opuntia ficus-indica, Croton macrostachyus, Ficus sycomorus, Schinus molle* L, *Acacia bussei, Parkinsonia aculeate, Carrisa edulis, Capparis erythrocarpus, Ximenia Americana, Acacia sieberiana, Ficus vasta, Terminalia glauceslcens, Grewia ferruginea* and*Syzygium guineense* (Fig 1). Dearth period can deviate in response to variation in soil type and climatic situation. The scarcity period identified in current study is in agreement with finding of Haftom Gebremedhn *et al.,* 2013 [11]. The current study, however, vary from study of Assemu Tesfa *et al*., 2013 which indicated that the peak scarcity period of floral resource in western Amhara ranges during months of February, march and April [4].

Periodical dearth periods can lead to depletion of reserved food inside the hive. This can have a serious impact on productivity of honey bee. If supply of protein reach feed for queen bee is decreasing, frequency of laying eggs will also decrease. Brooding of worker bee will become minimal that can eventually lead to weakening of overall performance and strength in the hive.

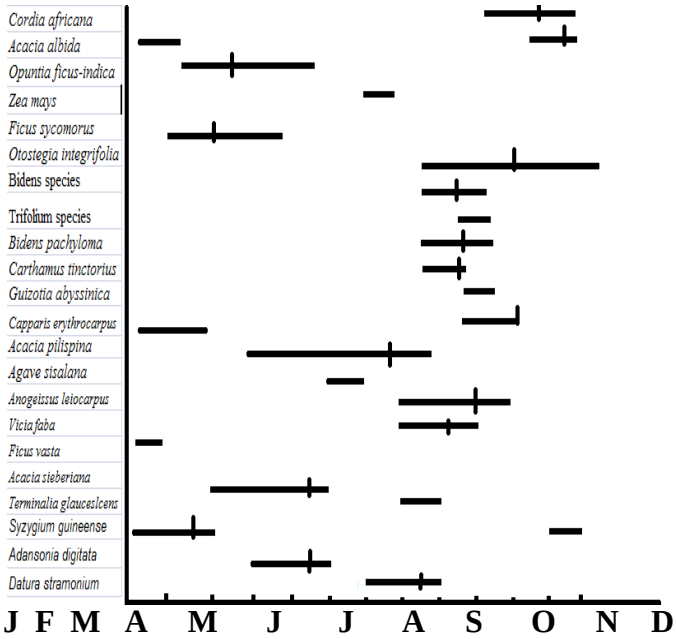

Fig 1. Flowering chart of main bee forages in T/Koraro Woreda (the vertical line indicate peak flowering period)

Majority of the studied plants were considered as basic sources of both pollen and nectar. According to direct observation and response from experts working in the study areas, plants species such as *Cordia africana, Dodonaea angustifolia, Acacia lahai, Carica papaya L., Mangifera indica L, Psidium guajava, Croton macrostachyus, Otostegia integrifolia,* Bidens species, Trifolium species, *Bidens pachyloma, Carthamus tinctorius***,** *Guizotia abyssinica, Brassica napus, Parkinsonia aculeate, Zizipus Spina-christi, Carrisa edulis, Jasminum floriban, Capsicum annum, Calpurnia aurea, Persea Americana, Mimusops kummel, Olea europaea, Agave sisalana, Anogeissus leiocarpus, Vicia faba, Datura stramonium, Syzygium guineense, Terminalia glauceslcens* were identified as a source of pollen and nectar for honey bees. This is in agreement with Huryn and Moller (1995), Bista and Shivakoti (2001), Alemtsehay Teklay (2011) and Abebe Jenberie *et al*., (2014) [23], [16],[3],[1].

Whereas, some of the plants species like *Eucalyptus camaldulensis, Persea americana and Ficus vasta* were considered as a source of nectar. A similar result is also obtained by Alemtsehay Teklay (2011) in case of *Ficus vasta* [3].

3.7. *Propagation techniques*

The most common means of propagation techniques existing for the identified plants was seedling, wildings, sowing, cutting, and budding on to rootstock and air layering. Majority of the species (66.67%) can be propagated through seedling followed by wilding (15%).

3.8. *Classification of honey bee forages*

The respondents identified various honey bee forage based on their relevance and number of bee visits to honey bee.

Accordingly, farmers, experts and honey bee technicians classified the plants as major, medium and minor.

3.8.1. *Major honey plants*

The survey result indicated that 16 honey bee flora was classified as major honey plants grown in T/Koraro woreda of north western zone of Tigray. The classification made to the species *Zizipus Spina-christi,* Bidens species, *Parkinsonia aculeate, Cordia africana* as major feed source for honey bees agrees with the findings made by Tewelde Gebremichael (2006) in Atakilty kebelle based on farmers and experts ranking [19].

The species distribution of *Parkinsonia aculeate, Zizipus Spina-christi and Grewia ferruginea* iscomparatively higher than the other species classified as major honey plants in the study area. Because the above species can grow easily in various soil types with variation in organic contents such as cultivated areas, grazing lands and communal lands (Table 2). The communal lands encompass closed forest area, hill sides, plateaus and mountainous areas. The species *Terminalia glauceslcens* demand greater focus as it found very rarely in the area. This may be associated with deforestation and increasing trend in population density that utilized the plant for various purposes including fuel without any rehabilitation measures.

Table 2. Major honey plants identified based on questionnaire survey

No	Species name	Distribution	Abundance
1	*Cordia africana*	Backyard and communal area	1
2	Bidens species	Grazing and communal lands	2
3	Trifolium species	Cultivated land	2
4	*Carthamus tinctorius*	Cultivated land	1
5	*Parkinsonia aculeata*	Cultivated, grazing and communal lands	2
6	*Zizipus Spina-christi*	Cultivated, grazing and communal lands	1
7	*Carrisa edulis*	communal lands	3
8	*Mimusops kummel*	Grazing and communal lands	3
9	*Diosypros mespiliformis*	Grazing and communal lands	3
10	*Acacia sieberiana*	communal lands	3
11	*Terminalia glauceslcens*	Grazing lands	5
12	*Grewia ferruginea*	Cultivated, grazing and communal lands	2
13	*Buddleja polystachya*	communal lands	3
14	*Syzygium guineense*	communal lands	3
15	*Carica papaya L.*	Irrigated land	3
16	*Opuntia ficus-indica*	communal land	3

**Remark Abundance level: highly abundant (1), abundant (2), medium (3), few(4), very few(5)

3.8.2. *Medium sourced honey plant species*

As to the respondents of the study area, a total of 13 species were identified as secondary sources for bees. The classification made for *Acacia bussei* as medium sourced honey forage is in agreement with finding of Tewelde Gebremichael (2006) [19]. Species named *Croton macrostachyus, Eucalyptus camaldulensis* were distributed at various soil types as compared to other medium source plant species. The relative abundance of *Zea mays, Ximenia Americana* and*Acacia bussei*is greaterthan others (Table 3). The species *Acacia pilispina, Citrus sinensis pers, Schinus molle* L., however, demands greater focus as they found scatter in area with comparatively small in amount.

Table 3. Honey plants identified as secondary sources of feed for bees as to questionnaire survey

No	Species name	Distribution	Abundance
1	*Eucalyptus camaldulensis*	Grazing and communal lands	2
2	*Croton macrostachyus*	Cultivated, grazing and communal lands	3
3	*Schinus molle* L.	communal land	4
4	*Acacia bussei*	Grazing and communal land	1
5	*Anogeissus*	communal land	2
6	*Ximenia americana*	communal land	1
7	*Citrus sinensis* ners	Irrigated land	4
8	*Mangifera indica L*	Irrigated land	3
9	*Psidium guajava*	Irrigated land	3
10	*Zea mays*	Backyard and irrigated lands	1
11	*Acacia pilispina*	Grazing and communal land	4
12	*Vicia faba*	Cultivated land and rain fed	3
13	*Ficus vasta*	Grazing and communal lands	4

**Remark Abundance level: highly abundant (1), abundant (2), medium (3), few (4), very few (5)

3.8.3. *Minor sources*

A total of 8 species were classified as minor or comparatively not suitable for honey bee consumption according to farmers, development agents, honey bee technicians and experts available in the study area (Tble 4). These include *Acacia lahai*, *Dodonaea angustifolia, Ficus sycomorus, Maytenus arbutifolia, Cirsium vulgare, Calpurnia aurea, Persea americana* and *Otostegia integrifolia*. Despite their adaptability to various soil types such as Cultivated, grazing and communal lands; the species *Cirsium vulgare and Maytenus arbutifolia* demands greater focus as they can help maintain species diversity in the area.

Table 4. Minor sources of feed for honey bees as to the base from questionnaire survey

No	Species name	Distribution	Abundance level
1	*Acacia lahai*	Grazing and communal lands	3
2	*Dodonaea angustifolia*	Grazing and communal lands	1
3	*Ficus sycomorus*	Grazing and communal lands	2
4	*Otostegia integrifolia*	Grazing and communal lands	1
5	*Cirsium vulgare*	Cultivated, grazing and communal	4
6	*Calpurnia aurea*	Grazing and communal lands	2
7	*Persea americana*	Irrigated land	3
8	*Maytenus arbutifolia*	Cultivated, grazing and communal lands	4

**Remark Abundance level: highly abundant (1), abundant (2), medium (3), few (4), very few (5)

4. Conclusions

Food security can be achieved by maximization of income of the households through looking all the options available. The current study revealed bee keeping as one potential source of income for households in the study area. To exploit the above potential, assessing honey bee floral resource is mandatory. A total of 51 species belonging to 37 families were identified in T/Koraro of North western zones of Tigray. These species were further classified based on their life forms as trees, shrubs, crop and spices and flowering weeds. The propagation techniques which were identified through consulting secondary sources for the above species include seedling, wildings, sowing, cutting and budding on to rootstock and air layering.

Based on direct observation and questionnaire survey, floral chart for the above species was established. Accordingly, the scarcity period ranges from August to June. Dearth period was characterized by shortage of major floral sources with shortage or absence of rainfall, dried environment and relatively hot temperature.

Recommendations

As the current study was based on direct observation and questionnaire survey, it may not encompass all economically important honey plants. Therefore, further study on pollen and comparative analysis is recommended.

Improving honey productivity relies on availability of major honey plants. Therefore, the current bee keeping practices should be integrated with crop cultivation and natural resource conservation in the study area.

Further training for experts and farmers on seasonal forage plant management and propagation of major honey plants is also required

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Haftom Kebede [a] and Samuel Gebrechirstos[b]

[a]*Department of Biology,Aksum University,Aksum,Ethiopia*
[b] *Department of Biology,Aksum University,Aksum,Ethiopia*

a. AksumUniversity Department of Biology:Email;tom.kebede@gmail.comtell: +251-920430553: Pobox:1010
b. Aksum University Department of Biology: Email; samiremix@gmail.com tell:+251-912849206 Pobox:1010

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