

Ecological Phytogeography: A Case Study of *Commiphora* Species

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Abstract

The present paper stipulated phytogeography, ecological ranges, possible origin and migratory route of *Commiphora* Jacq. species. Data were gathered from the field, herbarium and secondary sources. Information on distribution, altitude and soil preferences were compiled and aggregated together. Phytogeographical aspect of the group has been analyzed using Brooks's parsimony analysis (1990) which was done by tabulating flora regions versus the species under consideration where the matrix has been filled as either presence or absence. The result of data on phytogeography showed three patterns of distribution. Based on the plate tectonic theory, evolution and diversification of most angiosperm families into consideration, the origin of *Commiphora* has been discussed in details. It was recommended that the migratory route of *Commiphora* still requires further investigation and needs to be corroborated with data on the age of the genus and that of the concept of plate tectonic theory.

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INTRODUCTION

The genus *Commiphora* Jacq. is one of the most diverse genera of the family Burseraceae. It is largely represented in Africa where it is confined to arid and semi-arid areas. *Commiphora* also occurs in Iran, Pakistan, Peninsula India, Sri Lanka and Brazil. The genus is co-dominant with *Acacia* over the huge areas of the Horn of Africa and supports the large livestock populations of pastoral and agro pastoral communities. Of the 190 or so species in the genus, more than half of the species are native to the Horn of Africa. This might support the notion that the center of genetic diversity of the genus is in this part of the world.

In earlier days attempts have been made to circumscribe the genus, among others, Berg (1862), Engler (1898, 1904, 1910, 1912, 1931 and 1931), Sprague (1927), Chiovenda (1932), Burt (1935), Leenhouts (1956), Wild (1959 and 1963), Van der Walt (1973 and 1986), Gillett (1980 and 1991) and Boulos (2000) are the ones to be mentioned. However, information on the phytogeography, niche ranges, possible origin and migratory route of the group has not been treated in the past. Thus, the present paper aimed at dealing with the

mentioned information taking the genus *Commiphora* into consideration.

MATERIAL AND METHODS

Studies on NE and E Tropical African species of *Commiphora* were made (Table 1 for the nomenclature of taxa). Data were gathered from the intensive field works, herbarium specimens with the consultations of various literatures. Information on distribution, altitude and soil preferences were compiled and aggregated together. Phytogeographical aspect of the group has been analyzed using Brooks's parsimony analysis (1990). This was done by tabulating flora regions versus the species under consideration where the matrix has been filled as either presence or absence.

The geographical areas included under the present investigation were NE (North East which refers to Ethiopia and Eritrea) and E (East referring to Kenya, Tanzania and Uganda) Tropical Africa. Because of the transgressing nature of *Commiphora* species to the adjacent Somalia, Somalia was also included in the map for discussion purposes. The description of the regional floristic divisions of the

flora areas (i.e., Ethiopia, Eritrea, East Africa and Somalia) followed Hedberg and Edwards (1989), Polhill (1988) and Thulin (1999) as given in Figure 1.

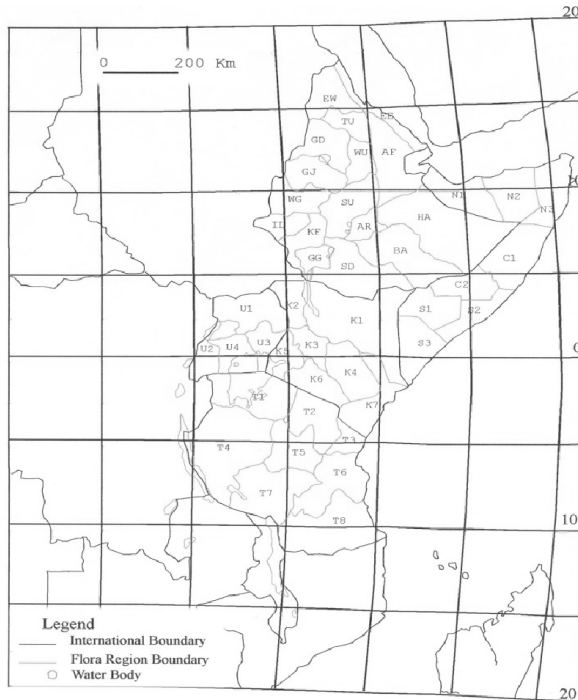


Figure 1: Regional floristic divisions of Ethiopia, Eritrea, East Africa and Somalia.

RESULTS AND DISCUSSION

Phytogeography

The majority of the species of *Commiphora* are essentially pan tropical in their distribution extending from Brazil via Tropical Africa to India and Pakistan with their high concentration in the Horn of Africa. On the account of the subdivision of African phytochoria of White (1983), the genus is found distributed in the majority of the regional centers of endemism, regional mosaic and transitional zones, with the highest genetic diversity in the Somalia-Masai regional center of endemism. Accordingly *Commiphora* species are found in Zambezan regional center of endemism, the Sudanian regional center of endemism, the Somalia-Masai regional center of endemism, the Karoo-Namib regional center of endemism, the Zanzibar-Inhambane regional mosaic, the Kalahari-highveld regional transitional zone, the Tongaland-Pondoland regional mosaic, the Sahel regional transition zone and the Sahara regional transition zone. However, some species like *C. myrrha* is transcontinental and extends its distribution to Arabia and India.

Out of the species of NE and E Tropical African *Commiphora* currently dealt with, only a few of them are out of the Somalia-Masai regional center of

endemism. For example, *C. africana* has a wider distribution through out the continent. It occurs in Zambezan region, Sudanian region, Somalia-Masai region, Kalahari-Highveld region, Sahel region and the Sahara region. *C. africana* has been reported from more that 30 countries in Africa (van der Walt, 1975). Others like *C. schimperi*, *C. gileadensis*, *C. quadricincta*, *C. habessinica*, *C. kataf* and *C. myrrha* transgress beyond the continent and occur in Arabia having disjunct distribution. Two species, namely *C. monoica* and *C. suffruticosa* are endemic to Ethiopia; another two species, *C. oblongifolia* and *C. ovalifolia* are endemic to Kenya; six species, *C. madagascarensis*, *C. hornbyi*, *C. acuminata*, *C. engleri*, *C. spathulata* and *C. stolonifera* are endemic to Tanzanian flora (see Fig. 2).

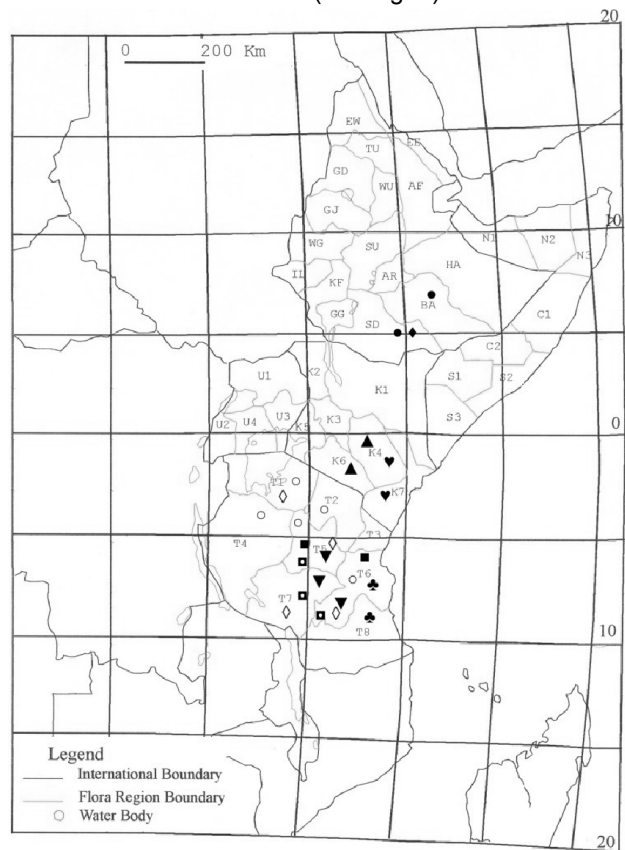


Figure 2: Distribution of endemic species of *Commiphora* in NE and East Tropical Africa in different flora regions. The symbols indicated in the map represent different species: ● - *C. monoica*, ◆ - *C. suffruticosa*, ▼ - *C. oblongifolia*, ▲ - *C. ovalifolia*, ♣ - *C. madagascarensis*, ▾ - *C. hornbyi*, ■ - *C. acuminata*, ○ - *C. engleri*, ◈ - *C. stolonifera*.

One approach of tracing the phytogeographic aspect of a given group is using Brooks's parsimony analysis (1990). In this analysis flora regions (areas)

versus species were tabulated on the data matrix and this has been generated from Table 1. Within the developed matrix absence and presence were considered. The data matrix was analyzed using PAUP Swofford (2002). The result obtained is reproduced in Figure 3.

The present gross distributional data for *Commiphora* of NE and E Tropical Africa (Figure 3)

shows three types of pattern. The first type is the EW-GG group that is characterized by wide spread distributional pattern and know to have few species of *Commiphora*. In this group few *Commiphora* species are distributed such as *C. africana*, *C. habessinica*, *C. edulis* and *C. schimperi* that normally occurs elsewhere in the different areas.

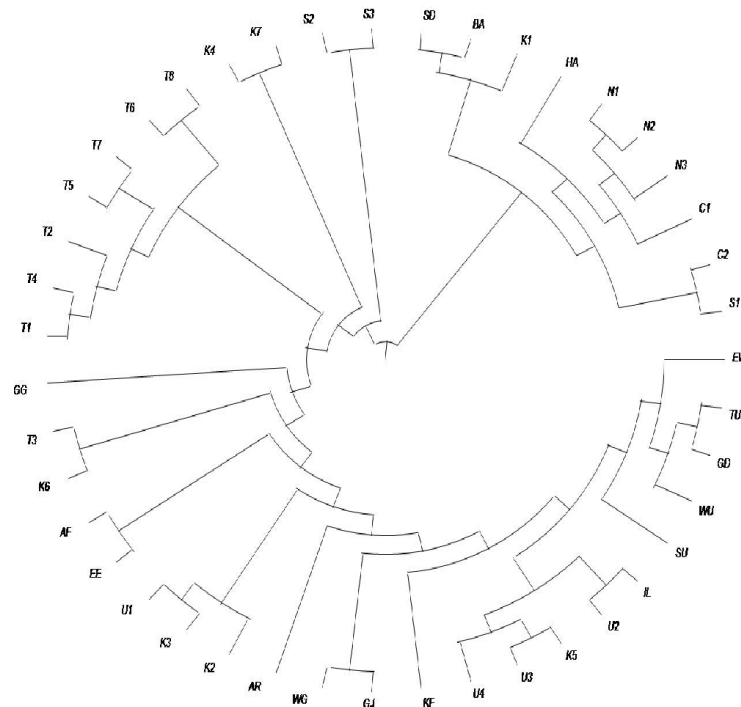


Figure 3: The areagram obtained using BPA.

The second group, T1-S3 (Figure. 3), is partly Tanzanian and characterized by group with very limited distributional pattern. Some species occurring in these areas are more or less endemic (such as *C. madagascarensis*), others are transgressing ones that transgress down to Southern African region and still some display very limited pattern of distribution. The transgressing species include *C. mollis*, *C. mossambicensis* and *C. mombassensis*.

The third group, SD-S1 group (Figure. 3), is the pattern displayed by most *Commiphora* species. About 70 % of *Commiphora* occurring in NE and E Tropical Africa are found distributed in these regions. Examples to this pattern are *C. hildebrandtii* and *C. ogadensis*. This perhaps seems to be the appropriate environment that suits many *Commiphora* species to survive, diversify and invade the region. Except for the political boundaries these areas are almost adjacent to one another and sharing similar ecological niche that support similar life forms.

Possible Origin and Migratory Route

The phylogenetic study of *Commiphora* species reported by Teshome (2005) presumably indicated that the primitive group with in the sections belongs to section *Cupulares* which contains *C. erangeriana*, *C. monoica*, *C. erosa*, *C. eminii*, *C. hornbyi*, *C. unilobata* and *C. zanziberica*. In addition to this evidence, the Horn of Africa harbors all sex forms that occur in the genus; i.e. hermaphrodite, monoecious and dioecious with the possible intermediate groups and the xerophytic and mesophytic species of *Commiphora* also occur in the NE and E Tropical Africa. Apparently it is possible to make the presumptuous assumption that the Horn of Africa is the origin of the group, with more emphasis to the NE of Africa. Although Wild (1965), didn't explicitly pointed out about the origin of the genus, he indicated that the occurrence of very dry interpluvial periods in Africa put pressure on the genus *Commiphora* to produce xerophytic species now well represented in NE and SW Africa, some of which migrated without difficulty through

Table 1: Altitudinal ranges, average annual rainfall, pedological preference and distribution of *Commiphora* species.

Scientific name	Altitudinal range in m	Annual Rainfall in mm	Pedological preference	NE	K1-7	T1-8	U1-4	S	CWS-Africa
<i>C. acuminata</i> Mattick	750-900	600-750	rocky slopes			56			
<i>C. africana</i> Engl.	2-2100	200-850	sandy to loamy, recent lava flows	EE, AF, EW, TU, GD, WU, SU, KF, GG, SD, BA, HA	K1-7	T1-8	123	N12C1S3	Tropical and southern Africa
<i>C. alaticaulis</i> Gillett and Vollesen	300-1200	200-450	sandy, rocky lime stone	SD,BA,HA	2			N2C2S1S3	
<i>C. albiflora</i> Engl.	700-1000	200-350	sandy, rocky lime stone	SD,BA				C2S2	
<i>C. baluensis</i> Engl.	600-1700	450-800	sandy, black cotton, rocky slopes	EF, AF, SU, AR, GG, SD, BA, HA	1467	23			Sudan
<i>C. boranensis</i> Vollesen	750-1450	250-450	rocky limestone, black cotton	SD, BA, HA	1			N1S1S2	
<i>C. bruceae</i> Chiov.	150-1100	200-280	alluvial sand	SD, BA, HA	127	3		N1-3C1-2 S1-3	
<i>C. caerulea</i> B.D. Burt	500-1500	450-700	sandy			14567			Malawi, Zimbabwe, Botswana
<i>C. campestris</i> Engl.	50-1200	230-800	sandy, rocky lava hills, alluvial	SD	1467	2356		C2S1-3	
<i>C. chaetocarpa</i> Gillett	200	230	sandy		1			C2	
<i>C. ciliata</i> Vollesen	700-1250	300-450	rock lime stone hills	SD, BA	1			C1-2S1	
<i>C. confusa</i> Vollesen	150-1300	300-700	sandy, rocky slopes	GG, SD, BA	12467	3			
<i>C. corrugata</i> Gillett and Vollesen	300-1450	250-380	rocky limestone	SD, BA, HA	1			C2S1	
<i>C. cyclophylla</i> Chiov.	300-800	200-300	sandy, limestone slope	SD, BA, HA	1			N2-3C1-2 S1	
<i>C. danduensis</i> Gillett	450-1600	250-700	sandy	SD	1				
<i>C. edulis</i> Engl.	2-1400	350-900	sandy, rock slopes	SD, GG	123467	1234567	1	S1-3	Zambia, Malawi, Mozambique, Botswana, South Africa
<i>C. ellenbeckii</i> Engl.	300-1200	230-350	sandy, rocky slopes	SD, BA, HA	1			N1-3C1-2 S1-2	
<i>C. eminii</i> Engl.	100-1750	550-1200	rocky hills, limestone		467	12345678			Zambia, Malawi, Mozambique
<i>C. engleri</i> Guillaumin	870-1650	450-800	rocky hills			12456			
<i>C. erlangeriana</i> Engl.	250-700	230-250	rocky limestone, gypsum slope	SD, BA	1			N1-3C1-2 S1	
<i>C. erosa</i> Vollesen	200-400	230-300	gypsum hills, alluvium limestone	SD, BA	17			C2S1-3	
<i>C. fulvotomentosa</i> Engl.	200-1050	800-1000	rocky outcrops			68			
<i>C. gileadensis</i> C. Chr.	150-750	200-350	rocky hills, sand dunes	EE, HA				N1-3C1-2 S1	Egypt, Sudan
<i>C. glandulosa</i> Schinz	5-950	650-950	rocky slopes			568			Zaire, Angola, Zambia,

										Malawi, Mozambique, Namibia, Botswana, Zimbabwe, South Africa
<i>C. gowello</i> Sprague	350-1400	200-350	sandy, stony soil	SD, BA, HA						N1-2C1-2 S1
<i>C. gracilispina</i> Gillett	350-400	230	sandy loam		1					N1-3C2S2
<i>C. guidottii</i> Chiov.	250-400	230-250	gypsum soil, stony slope	SD, BA						N2-3C1-2 S1
<i>C. gurreh</i> Engl.	750-1500	200-500	black cotton, rocky lime stone	SD, BA	1					N1-3C1-2 S1-2
<i>C. habessinica</i> Engl.	500-1900	300-900	sandy to loamy, black cotton	EE, EW, TU, WU, GD, GJ, SU, WG, IL, GG, SD, BA, HA	123467	123567	12		N1N2	Zambia, Malawi, Zaire, Rwanda, Burundi, Djibouti
<i>C. hildebrandtii</i> Engl.	850-1500	300-550	rocky lime stone slopes	SD, BA						N1-3 C2S1-2
<i>C. hodai</i> Sprague	400-650	230-250	red sandy soil	HA						N1-2C1-2 S1
<i>C. hornbyi</i> B.D. Burt	380-1220	450-750	sandy soil			567				
<i>C. horrida</i> Chiov.	500	250	sandy soil	HA						C1C2S2
<i>C. katar</i> (Forssk.) Engl.	260-1650	300-500	drained sandy soil		123	2				All except S3
<i>C. kua</i> Vollesen	90-1000	230-350	sandy soil, rocky slopes	EE, AF, SD, BA, HA,	147					N1-3C1-2 S1S3
<i>C. lindensis</i> Engl.	5-960	600-950	sandy soil		47	368				S2S3
<i>C. madagascarensis</i> Jacq.	5-660	750-950	rocky slopes			68				
<i>C. merkeri</i> Engl.	700-1600	300-400	sandy, black cotton soil		6	2				
<i>C. mildbraedii</i> Engl.	450-1650	500-700	rocky places, black cotton	BA	147					
<i>C. mollis</i> Engl.	540-1500	400-900	sandy soil, black cotton			1245678				Zaire, Angola, Zambia, Malawi, Mozambique, Namibia, Botswana, Zimbabwe, S. Africa
<i>C. mombassensis</i> Engl.	125	900	coastal dunes			8				Mozambique
<i>C. monoica</i> Vollesen	1000-1400	250-450	rocky limestone, black cotton	SD, BA						
<i>C. mossambicensis</i> Engl.	390-1660	500-800	sandy soil, black cotton			1245678				Zambia, Malawi, Mozambique, Botswana, Zimbabwe
<i>C. myrrha</i> Engl.	250-1300	230-350	sandy to loamy, rocky lava hills	AF, SD, BA, HA	1					N1-3 C1-2 S1
<i>C. oblongifolia</i> Gillett	600-1050	500-600	rocky hills		47					
<i>C. obovata</i> Chiov.	150-1050	300-400	rocky lime stone hills	SD, HA	7					N1C2
<i>C. oddurensis</i> Chiov.	400-600	200-250	limestone slopes		1					C1-2S1-2

<i>C. ogadensis</i> Chiov.	500-1450	350-650	sandy soil, black cotton, alluvial	SD, BA, HA	1				N1-3 C2S1-2
<i>C. ovalifolia</i> Gillett	800-1400	600-800	rocky slopes		46				
<i>C. paolii</i> Chiov.	50-700	200-350	alluvial sand	SD, BA, HA	147				C1-2S1S3
<i>C. pedunculata</i> Engl.	200-1000	450-800	sandy soil	GD, GJ, WG		78			Mali to Sudan, Malawi, Zambia
<i>C. pteleifolia</i> Engl.	1-1100	700-950	rocky escarpment		7	3468			Zaire, Zambia, Mozambique
<i>C. quadricincta</i> Schweinf.	40-750	200-350	sandy, rocky slopes, lava hills	EE, AF, EW					Nigeria, Chad, Sudan
<i>C. rostrata</i> Engl.	80-1350	200-450	sandy soil, rocky slopes	GG, SD, BA, HA	147				N1-3C1- 2S1-2
<i>C. samharensis</i> Schweinf.	150-400	150-250	sandy and rocky hills	EE, GG					In all Sudan
<i>C. sarandensis</i> B.D. Burt	750-1300	350-450	stony soils, hard-pan soils		1	1245			
<i>C. schimperi</i> Engl.	430-2100	450-850	sandy, rocky, black cotton soils	EW, TU, GD, WU, SU, GJ, SU, AR, GG, SD, BA, HA	123467	123567	1		N1C2 Zaire, Botswana, Zimbabwe, Mozambique, S. Africa
<i>C. sennii</i> Chiov.	200-900	200-400	alluvium soil		147				S1S2S3
<i>C. serrata</i> Engl.	2-700	800-950	rocky outcrops			68			Mozambique
<i>C. serrulata</i> Engl.	1000-1850	350-750	sandy soil, black cotton, basaltic soil	SD, BA, HA					N1N2
<i>C. spathulata</i> Mattick	550-1100	450-600	rocky slopes, red soil			567			
<i>C. sphaerocarpa</i> Chiov.	250-400	200-250	gypsum slope, rocky limestone	SD, BA, HA					N1-3 C1- 2S1
<i>C. sphaerophylla</i> Chiov.	400-800	230-350	sandy soil, rocky slopes	HA					N1-2 C1- 2S1
<i>C. staphyleifolia</i> Chiov.	250-400	200-250	alluvial sand	SD, HA					C2S2
<i>C. stolonifera</i> B.D. Burt	690-1260	450-550	sandy soil			1567			
<i>C. suffruticosa</i> Teshome	1000-1450	230-400	sandy soil, rocky slopes	SD					
<i>C. swynnertonii</i> B.D. Burt	750-1100	250-550	sandy soil		1	5			
<i>C. terebinthina</i> Vollesen	200-1800	300-800	sandy, rocky, black cotton soils	KF, GG, SD, BA, HA	123467	2	1		N1-3C1- 2'S1-3
<i>C. truncata</i> Engl.	600-1050	250-400	sandy, stony soil	HA					N1-2C1-2 S1
<i>C. ugogensis</i> Engl.	800-1400	500-800	sandy soil			12457			Zambia, Zimbabwe
<i>C. unilobata</i> Gillett and Vollesen	70-1000	200-350	alluvium soil	SD	147				C2S1S2
<i>C. velutina</i> Chiov.	400-900	230-300	sandy soil, limestone hills, old lava flow	AF, SD, HA	1				N1-3C1-2 S1S3
<i>C. zanzibarica</i> Engl.	2-510	900-1050	coral rocks near sea & streams		7				Mozambique, Malawi, Zimbabwe, S. Africa

Arabia (with six species of the Horn currently occurring in Arabia) to India (one species of the Horn which was cultivated occurs there) and are represented today by species such as *C. wightii* (synonym of the then *C. mukul*) and *C. berryi*. Further more species that currently occur in India include *C. caudata*, *C. agallocha*, *C. pubescens* and *C. myrrha* (Chithra and Henry, 1997).

The transoceanic distribution of *Commiphora* from the mainland in Madagascar, India and Arabia on one side and to Latin America on the other side is another remarkable feature of the group to be portrayed here. In connection with phytogeography the land bridge theory has been stipulated by several authors, notably van Steenis (1962), Wild (1965), Takhtajan (1969), Raven and Axelrod (1974), Schuster (1976), Turner (1995), Ridder-Numan (1996) and Haegens (2000) including literatures cited therein.

According to Raven and Axelrod (1974) and literatures cited therein, the separation of Africa from South America seems to have commenced 125-130 m.y. BP. The final marine connection associated with the spreading apart of Africa and South America took place slightly less than 100 m.y. BP with the continent remaining in near contact along strike-slip faults until at least 90 m.y. BP, when northeast Brazil and Africa were separated by only a narrow strait. The same authors adopted the concept that Africa and Europe were connected via Spain, in Early Paleocene (63 m.y BP). Africa may have been connected with Asia through Arabia at this time. Finally they came to the notion that from the Early Paleocene into the Upper Eocene (53 m.y. BP), Africa and Europe seem to have become more widely separated. Furthermore Schuster (1976) and literatures cited therein suggested that until at least 75 million (roughly Late Cretaceous) years ago there were archipelagic connections between the Indian plate, the Mascarene Plateau, Madagascar and Africa. During this same period, India and Australia continued to move northward towards Eurasia, opening the Indian Ocean and beginning to close the Tethys Ocean. As India separated from the southeast coast of Africa it pulled Madagascar in its wake.

Following this plate tectonic events, the pattern of evolution and distribution of organism has been considered as events of great importance. Raven and Axelrod (1974) indicated that direct migration of organism between Africa, Madagascar (probably also India) and South America last possible about 100 m.y. BP and also reestablishment of direct connection between Africa and Eurasia was about 17 m.y. BP. Rabinowitz *et al.*, (1983) and literatures cited therein, attested that the magnetic data point

to the motion of Madagascar relative to Africa being from the north, with the Africa-Madagascar separation started beginning during the time of the Jurassic quiet zone (~165 Ma) and ending at a time of formation of anomaly M9 (~121 Ma) denoting that the Africa-Madagascar separation began at about the same time of as the breakup of Gondwanaland and the separation of North America from Africa. On the other side, Storey *et al.*, (1995) dated the separation of Madagascar and India before ~ 88 Ma. However, recent studies of the Mozambique channel, revealed the possibility of the land bridge connecting mainland Africa and Madagascar from mid-Eocene to early Miocene (45-26 Ma) (McCall, 1997 as cited in Möller & Cronk, 2001). On the other hand authors like Coleman *et al.*, (1992), Tadiwos Cherinet *et al.*, (1998) and Ukstins *et al.*, (2002) dated the separation of Africa-Arabia to 30-20 Ma range. From the above geological dating of separation events, one can come to the conclusion that the separation of Madagascar predates that of Arabia from Africa. This geological episode can be augmented by the presence of 6 *Commiphora* species in Arabia that also occur in the Horn as opposed to the endemic species of *Commiphora* in Madagascar. This shows that the Arabian species of *Commiphora* migrate recently to Arabia than to the rest of the world which still is in favor of the geological time of the separation of the two continents.

Correlation of continental separation with that of the fossil evidence might be the best evidence for the biogeography of a given group. However, the fossil records of a tropical family, Burseraceae, is very scanty with the available ones most from north temperate zone latitude, i.e. a little has changed since Muller (1981) suggested "at present only doubtful records of rare burseraceous pollen grains have been published, interpretation of which will depend on a future detailed study of the recent pollen morphology of this family." Nevertheless, Graham & Jarzen (1969) had recorded *Bursera simaruba* type pollen from Puerto Rico as Oligocene communities.

Furthermore, from the Eocene of Panama, Graham (1985) described *Tetragastris*-like pollen and *Protium*-like pollen, but this pollen (*Protium*-like) is considered as much more like *Chrysophyllum* L. pollen by Harley & Daly (1995). Taylor (1990) also reported 6-7 putative genera of the family *Burseraceae* which are of Paleocene to upper Eocene age which include pollen of putative *Protium* and *Tetragastris* and the leaves of putative *Bursera* showing that the probable age of the family with much reservation, from this scanty information, lies between Paleocene-Eocene.

Taking the separation of the continents and the meager information on the age of the family into consideration one could possibly assume that *Commiphora* migrate from the Horn of Africa to the different African regions, to Madagascar via the land bridge that was supposed to connect Africa and Madagascar, to Arabia and might or might not reach India. The recent report on the displacement of *Bursera leptophloeos* Mart. from *Bursera* to *Commiphora leptophloeos* (Mart.) Gillett comb. nov. of *Commiphora* Gillett (1980) indicated the existence of *Commiphora* species in Latin America. It is then impractical to assume that either *Commiphora* migrated from Africa to Latin America or from Latin America to Africa, for the fact that the separation of these two continents predates the evolution and diversification of most angiosperm families. One hypothetical explanation on the existence of *Commiphora* in Latin America and India might be linked to polyphyletic origin (note that the present study didn't consider the whole genus to confirm whether it is polyphyletic or monophyletic in origin) of *Commiphora* and that *Commiphora* might have derived from *Bursera* itself which is currently distributed in both places. The endemicity of the Madagascan species of *Commiphora* might suggest the possible speciation events in the area.

Wild (1965) on the other hand indicated that there are double patterns of distribution of *Commiphora* species: his first argument was that the occurrences of interpluvial periods in Africa produced xerophytic species that migrated to Arabia and India. His second argument for the notion was that the Lemurian land-bridge played its role since the more mesophytic species in one of the more

favorable pluvial periods migrated along the Lemurian bridge into Madagascar with its twenty or so species and also into India and Ceylon. The morphological resemblances of *C. wightii* to that of the section containing *Commiphora* (which contains *C. quadricincta*, a northern species and *C. madagascarensis*, *C. oblongifolia* and *C. ovalifolia* the Tanzanian species) may suggest a two way migration of species that go with Wild's (1965) notion.

In contrast to the different kinds of colonization event, another possible explanation of the distribution of species across the continent is long distance dispersal. Even if this process might happen (animal dispersal in this case) in the past, the viability of the seeds of *Commiphora* species is quite in question.

Vegetation, Altitudinal & Pedological Preference

Most, if not all, species of *Commiphora* in the NE of Africa occur in the southern and southeastern parts of Ethiopia. These include the lowlands of Hararge (HA in Figure 1), Bale (BA), Sidamo (SD), and some parts of Gamo Gofa (GG), with a high species concentration of *Commiphora* in Sidamo. Similarly, the East African species of *Commiphora* are highly concentrated in the Northern Frontier Province and the coast of Kenya in K1 and K7 as recognized in Flora of Tropical East Africa. High concentration of species occurs in T5 and T6 of Tanzania and U1 (around the Karamoja district of Uganda). Figure 4 shows comparison of the different flora regions in terms of the species abundances within the different political boundaries.

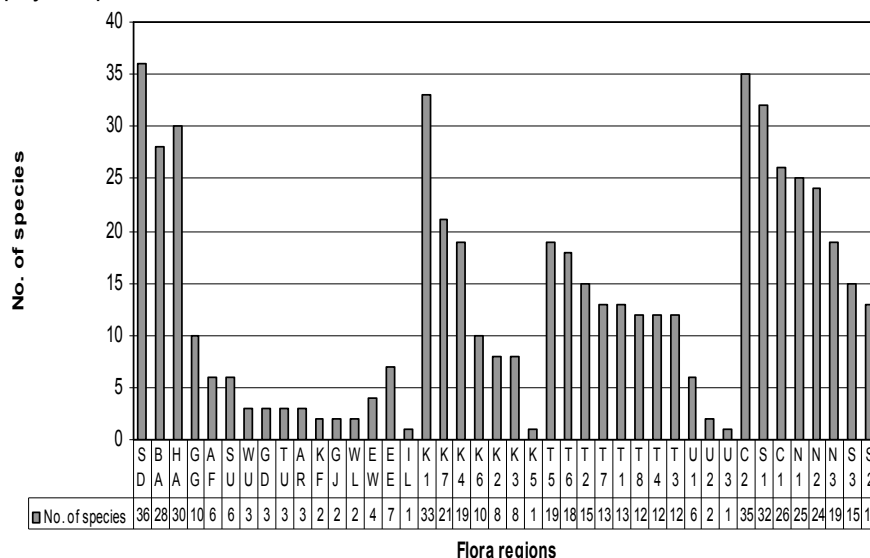


Figure 4: Comparison of different flora regions in terms of abundances of *Commiphora* species. The Flora regions are as recognized in the Flora of Ethiopia, Flora of Somalia and Flora of Tropical East Africa. Note also C2 of Somalia has high species concentration.

The vegetation of these areas, although not studied deeply, have been classified and mapped by various authors. The physiognomic study made by Pichi-Sermolli (1957) resulted in the recognition of 24 vegetation units in his publication on the geobotany of Ethiopia, Eritrea, Djibouti and Somalia. Of 24 vegetation units recognized by Pichi-Sermolli (1957), unit 2, 3, 4, 6, 7, 11, 12 and 13 were considered to, at least, occur in one or more areas of the lowlands of Hararge, Sidamo, Bale and Gamo Gofa. However, some of his units, particularly unit 6, 7 and 11 are generalized ones and could not exactly tell the nature of vegetation in the areas.

Breitenbach (1963) studied the vegetation of Ethiopia based on physiognomy in relation to altitude and humidity and came up with seven vegetation types including various sub-types. In this study he mapped the lowlands of Hararge, Bale,

Sidamo and Gamo Gofa under his lowland-woodland, lowland-savannahs and lowland-steppes units. Although Breitenbach (1963) identified seven major units, the borders drawn on the vegetation maps produced from his study is quite similar to the one produced by Pichi-Sermolli's (1957). The next comprehensive study of African vegetation was that of White (1983). According to White (1983) southern and southeastern Ethiopia belongs to the Somali-Masai Regional Center of Endemism, one of his major units within the flora of Africa as a whole. It is the home of *Commiphora* and *Acacias* extending down to Somalia, Kenya, Tanzania and Uganda. In this regional center different plant communities could be encountered. This includes *Commiphora-Acacia*, *Commiphora* woodland (as in the case of pure *Commiphora baluensis* woodland in El Siro area, Figure 5) and or *Commiphora* bushland.

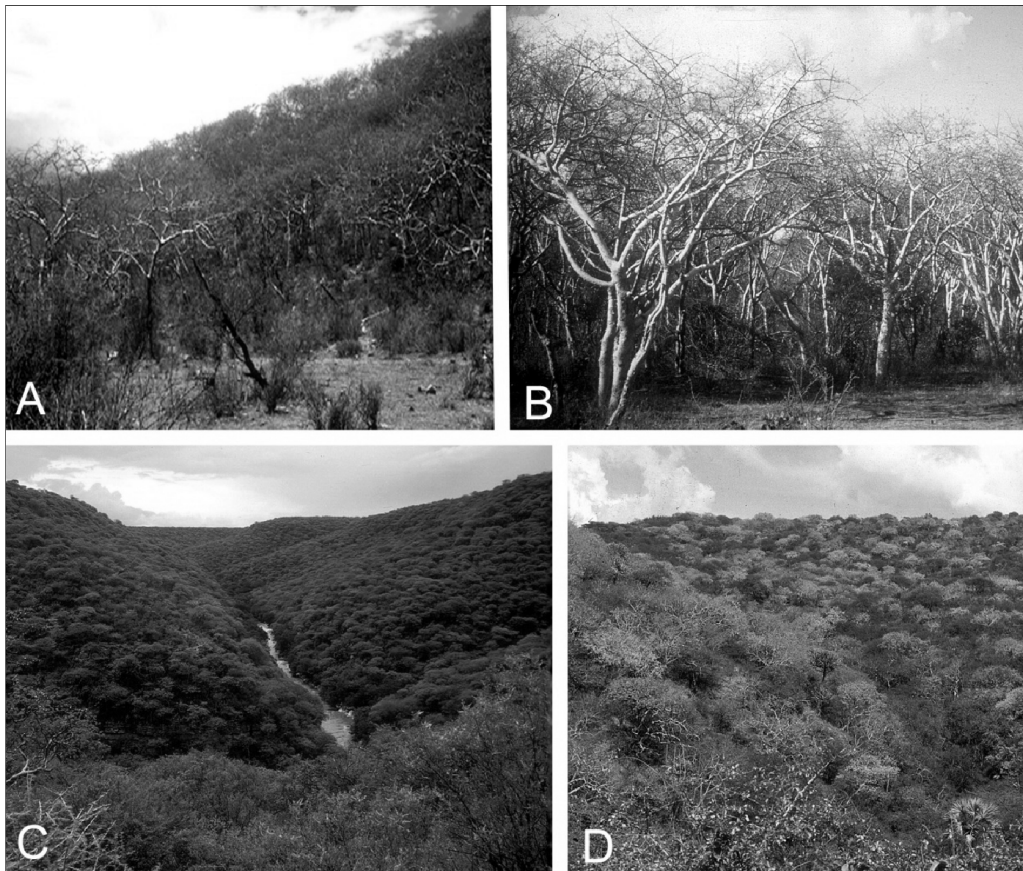


Figure 5: Some vegetation formations with *Commiphora* species. A-B, *C. baluensis* woodland; C, *Acacia-Commiphora* woodland around Sof Umar; Weyib river in the center; D, dry *Commiphora* woodland.

Generally speaking areas harboring *Commiphora*, belong to deciduous woodland and/or bushland usually conspicuously rich in species of *Acacia* and *Commiphora*. Associated with these vegetation types, there are extensive grassland

areas that are found at relatively higher altitudes, notably at Nagelle and Jijiga, which probably were formed as a result of anthropogenic influences in the past years. Altitudinally *Commiphora* occur from almost sea level to about 2000 m above sea level

(Table 1), on alternatively sandy soils, rocky hills, limestone, gypsum and sometimes on black cotton soils.

Further categorization of species based on the width of altitudinal niche they occupy shows that some species perform best in a wide range of altitude exploiting broader ecological niches while others preferably occur in a narrow range. Of all the

species considered here for investigation, 20 species occur within a 500 m altitudinal range showing narrow range of performances (e.g., *C. acuminata*, *C. chaetocarpa*, *C. gileadensis*, *C. erosa* and *C. suffruticosa*, Table 2) and 7 species occupy altitudinal range exceeding 1500 m utilizing all opportunity from lowland, premontane to low montane range and successfully invading the habitat.

Table 2: Categorical performance of species in terms of altitudes.

Ranges of altitudinal performance	Number of species	Examples of species in that category
Within 500 m range	20	<i>C. acuminata</i> , <i>C. erosa</i> , <i>C. suffruticosa</i> , etc.,
Within 500 – 1000 m range	29	<i>C. alaticaulis</i> , <i>C. albiflora</i> , <i>C. ciliata</i> , etc.,
Within 1000 – 1500 m range	17	<i>C. corrugata</i> , <i>C. gurreh</i> , <i>C. pedunculata</i> , etc.,
Above 1500 m range	7	<i>C. africana</i> , <i>C. edulis</i> , <i>C. schimperi</i> , etc.,

Commiphora are aridisols species, a soil type known to occur in dry areas in general and in lowlands of Oromia, Ogaden and southern Ethiopia in particular (Mesfin Abebe, 1998). Some species of *Commiphora* occur preferably in the woodland vegetation on brown soils, black cotton soils and on a rocky lava places. They form association with *Acacia*, *Boswellia*, *Combretum*, *Terminalia*, *Barbeya* and some species of *Lannea*. Some of these species of *Commiphora* include *Commiphora edulis*, *C. habessinica*, *C. pedunculata*, *C. engleri*, *C. serrulata* and *C. gurreh* with *C. pedunculata* being an exception as it also occurs in wooded grassland vegetation. Other species of *Commiphora* tend to occur in bushland vegetation forming an extensive association with *Acacia* and some *Acanthaceae*. Some notable species to this group are *C. acuminata*, *C. albiflora*, *C. campestris*, *C. ellenbeckii*, *C. horrida*, *C. sphaerocarpa*, *C. staphyleifolia* and *C. unilobata*. The bushland *Commiphora* largely occur on rocky lime stone hills. Other than the bushland or woodland species, some are widespread over both bushlands and woodlands frequently occupying sandy soil that overlay limestone. These species include the widespread *C. africana*, *C. baluensis* and *C. schimperi*. Other widespread species include *Commiphora boranensis*, *C. confusa*, *C. corrugata*, *C. cyclophylla*, *C. monoica*, *C. myrrha* and *C. rostrata*. *Commiphora corrugata*, *C. baluensis* and *C. rostrata* also occur in wooded grassland vegetation, which is primarily dominated by grass. Interestingly, *Commiphora corrugata* and *C. hildebrandtii* are species that often perform best with *Combretum molle* and *Terminalia brownii*.

Implications for *in-situ* Conservation

Commiphora form important and major parts of the vegetation in what is known as White's (1983)

Somalia-Masai Regional Center of Endemism. It is also the best sources of browse for the large livestock of the region. The need for trees that can be browsed coupled with the need for arable land in the areas may lead to degradation of their genetic diversity. Alluding to earlier discussion on the diversity of *Commiphora* species, flora regions like SD, HA, BA, K1, S1, C2 and C1 are regions of high genetic pool. Identification of rich centers of diversity is then important for undertaking *in-situ* conservation of the genetic resources. Regions with high diversity of *Commiphora* species could serve as a possible *in-situ* conservation site. Although considering all these regions for *in-situ* conservation seems to be expensive, regions that are endowed with greater genetic pool can be considered for conservation purposes. Good examples are Sof Umar in Bale and Walensu Ranch in Sidamo where 12 and 13 species of *Commiphora* have been recorded. Similar gene conservation activities can be made in the other regions having high genetic diversity of *Commiphora* species.

CONCLUSIONS

Commiphora are pan tropical in distribution performing well in arid and semi-arid environments occupying an ecological range between 1 – 2100 m above sea level striving best on aridisols. More over, some species of the genus tend to perform well in a narrow ecological range. Results from the phytogeographic analysis of the group revealed three patterns of distributions: species with wider distribution ranges, endemic and transgressing species having limited niche and those found in flora regions that are appropriate environment for *Commiphora* to diversify and invade the regions.

Although tracing the migratory route and possible origin of the group requires numerous information, studies such as Wild (1965) and Teshome (2005) suggested that the possible origin of *Commiphora* seems to be in the Horn of Africa. Based on the separation of the continents and the meager information on the age of the family into consideration it is possible to assume that *Commiphora* migrate from the Horn of Africa to the different African regions, Madagascar and Arabia. It seems practical to note that *Commiphora* did not migrate to Latin America nor vice versa, since the separation of African and Latin American continents predates the evolution and diversification of most angiosperm families showing that *Commiphora* might have polyphyletic origin. However, the migratory route of *Commiphora* still requires more data, particularly complete data of *Commiphora* of the world. Data on the age of the genus is also important to corroborate it with the plate tectonic theory.

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