FLORA AND VEGETATION OF NACHOLA, SAMBURU DISTRICT, NORTHERN KENYA: A STUDY OF VEGETATION IN AN ARID LAND

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ABSTRACT Although patchy vegetation of open grassland and closed woodland or forest is often reconstructed as a habitat of early hominids, there are few studies of modern vegetation of this type. Vegetational and floral study in Nachola, northern Kenya aimed to remedy this lack. It appeared to have 160 species, which accords well with treated physiognomical classifications of semi arid open vegetations in northern Kenya. There are two contrasting types of vegetation i.e. riverine forest and grassland. Riverine forest comprises two dominant species and several tree species. Grassland has less biomass and despite its name, grass is rare. Instead, dwarf shrubs of Labiatae dominate the surface of the land. Riverine forest in Nachola has two major species, both producing fruits edible to frugivorous mammals, *Ficus sycomorus* and *Acacia tortilis* ssp. *spirocarpa*. Fruit production is suggested to be greater in *F. sycomorus*. Possibility of early hominid habitats should be discussed based on such an analysis of modern equivalents.

Key Words: Arid land; Flora; Fruit; Pliocene hominids; Riverine forest; Vegetation.

INTRODUCTION

Coppens (1994) proposed the “East Side Story” hypothesis on the early evolutionary stage of human ancestry that was caused by the fragmentation of their forest habitat due to the uplift of the Rift System in East Africa, and its replacement by open grassland. This hypothesis is that the eastern part of the population at the time common to human ancestors and African apes was then forced to divide, and for early hominids to go out to more open vegetation or grasslands from reducing forests caused by the aridification, caused by the uplift of the Rift which began in the Middle Miocene. He pointed out that early hominids originated in this poor vegetation. This population should have survived in such grasslands, including food supplies nearby. For the early hominids refuge and food are most important. There have been many discussions on refuge and food, but it is clear that vegetational analysis is needed, especially in arid or semi arid land.

To mention a few hominoid sites of Kenya, in Rusinga Island in Lower Miocene, a dry forest or early stage of succession toward the forest or woodland was suggested by an analysis of paleosols (Retallack *et al*., 1995). An old study of this site (Chesters, 1957) showed a list of plant taxa, which suggests that the vegetation there had open gaps of forest, such as riverine forest or early successional stages. In Fort Ternan, slightly later than Rusinga Island, a famous site for *Kenyapithecus*, woodland was deduced on the basis of bovid morphology (Kappelman, 1991), and woodland with grassland from a study of land snails (Pickford, 1987). Almost the same horizon, the Nyakach Formation is reconstructed as mosaic of riparian forest and woodland with 300-500 mm rainfall annually on the basis of paleosols (Wynn & Retallack, 2001). There is evidence that some early hominids were forest dwellers. The 6 My-old *Orrorin tugenensis* is estimated to have been a forest dweller (Pickford & Senut, 2001) on the basis of colobine monkeys, together with

entire margined, large sized fossil leaves and large sized trunks (Pickford, pers. comm.). The Tugen Hills have also other fossil plants. Kingston *et al.* (2002) reports tree fragments of forest species in 7-6 Ma, Jacobs & Winkler (1992) describes forests from 12.6 My-old deposits and Jacobs & Kabuye (1987) describe a forest assemblage aged 12.2 Ma. However, hominids between 4 and 3 Ma occupied more open habitats as evidenced by stable carbon analyses (Wynn, 2000, 2004), pollen analysis (Bonnefille, 1984), and mammal dental morphology (Macho *et al.*, 2003). Wynn (2000, 2004) proposed open low tree-shrub "savanna" vegetation for the paleoenvironment of *Australopithecus anamensis* in Kanapoi. Wynn (2004) estimated precipitation in Kanapoi (4.3-4.0 Ma) and the Kataboi Member of the Nachukui Formation (3.4-3.6 Ma) as 620 ± 100 and 550 ± 130 mm, respectively.

Thus, patchy, or mixed open and closed vegetation is the probable modern analogue for the habitat of early hominids in the Pliocene. Unfortunately forests and grasslands in East Africa have been poorly studied, neither quantitatively nor qualitatively although they should have not only for the understanding of ecosystems themselves, but also for the historical development with early hominids. Therefore, a study of flora, or qualitative composition of plants in arid and semi arid areas is of great value. However, few studies of East African arid or semi arid lands in northern Kenya have been done in regards of their flora or vegetation. In Turkana District, there is only a rough description of an exploration mostly from the air (Hemming, 1972). In the east, Marsabit District, only a study of vegetation in Samburu Isiolo Game Reserve by Barkham & Rainy (1976) has been found.

Riverine forest is the most forested component in arid and semi arid lands and potentially an important resource for refuge and food. As for riverine forest vegetation type, Kinnaird (1992) reported phenology in Tana River, Coast Province, Kenya. Mathooko & Kariuki (2000) studied the riverine forest of Njoro River, Nakuru District, Rift Valley Province, Kenya, but it is sub-montane vegetation, more humid and higher than in the kind of area supposed to be the habitat of Pliocene hominids.

The objective of this study is to give a better basis to discuss of the patchy or mixed vegetation of riverine forest and open grassland in semi arid land, which may apply for survival of Pliocene hominids in seasonal and arid environments. In this paper, I present flora and vegetation of Nachola, Samburu District, Northern Kenya. This area is arid or semi arid land with some riverine forests and suitable for such a study, because there is limited human disturbance from cultivation.

METHODS

Coordinates of the study are between N 01° 45' - 50', E 36° 40' - 50' (Fig. 1). It is located in the western end of El Barta Plain, altitude ca. 1200 m, with seasonal rivers, plains and rocky hills. West of this site is bordered by the eastern edge of the Great Rift Valley, named Samburu Hills. The main town of the plain is Baragoi, 13 km east of Nachola village.

In the area, no open permanent water exists, such as permanent rivers, marsh, pond or lake. In Nachola the river is well distinguished by the cliffs from the surrounding plains. The river bed is comprised of fine to coarse sand, occasionally of pebbles or basement rock.

The dominating drainage system of this plain is the Baragoi River and its tributaries, of which the main river begins near the north eastern foothills of the plain, runs south-

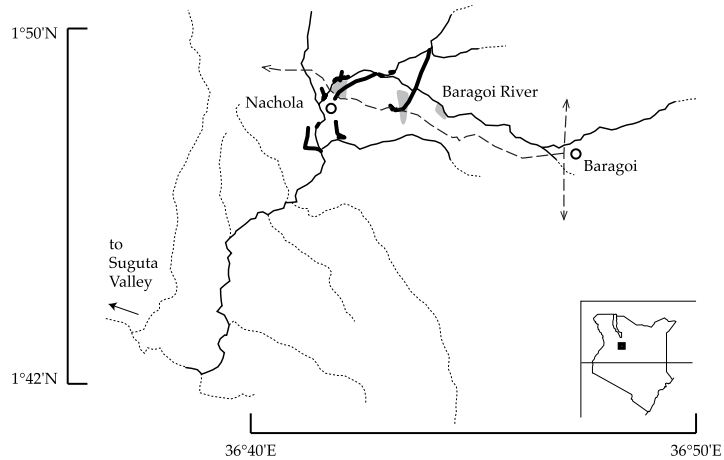

Fig. 1. Site map. Broad lines off and across rivers are locations of line transects. Thin lines are rivers of intensive research of flora. Dotted lines are other tributaries. Dotted line is the road from Baragoi town to Nachola village. Inset shows Kenya and the equator.

westerly to Baragoi town, then comes to Nachola village and down the escarpment making a gorge to the bottom of the Rift, Suguta Valley. Finally it disappears in the bottom of Suguta Valley by evaporation and seeping into the ground. No river, even the Baragoi River, is permanent, water flow is occasionally seen only after rainfall, and is not continuous, thus unpredictable.

Monthly precipitation data, with some missing months, measured at the meteorological station in Baragoi Town, Office of the District Officer at N 1° 47', E 36° 48' were obtained from the Meteorological Survey of Kenya (Fig. 2). Annual rainfall is 520 mm averaged over 21 years from 1980 to 2000. Two rainy seasons and two dry seasons are apparent in most years, but the wettest month and the intensity of the rainfall are quite unpredictable. The driest year, 2000, had only 252.8 mm precipitation, half of the average. The driest season from June to September, a slightly dry season from December to February, and two wet seasons, the longer one from March to May and the shorter one in October and November are recognized.

Ground water levels can be measured in water wells and boreholes in the river bed. At the time of field research in September 2002 in Baragoi River, it becomes shallower downstream. Ground water level in Baragoi town is 8 m below the river bed, 2 m below it in Nachola village, 4 m below between the town and village. Surface water is observed in the river bed 15 km downstream from Nachola village.

The salinity of the soil and water, which has a large effect on plant growth, is not measured directly, but it is assumed to be comparatively low. The residents of the village collect salt in the bottom of the Rift, the downward end of the river, not in El Barta Plain. The lack of saline tolerant species, such as *Hyphaene* spp. and Cyperaceae spp. also support this.

Herbivorous animals here are mostly livestock of native Turkana pastoralists as follows, goats, sheep, cattle, donkeys and camels. The numerous livestock seem to overgraze the vegetation here. Wild herbivorous vertebrates observed are savanna monkeys and

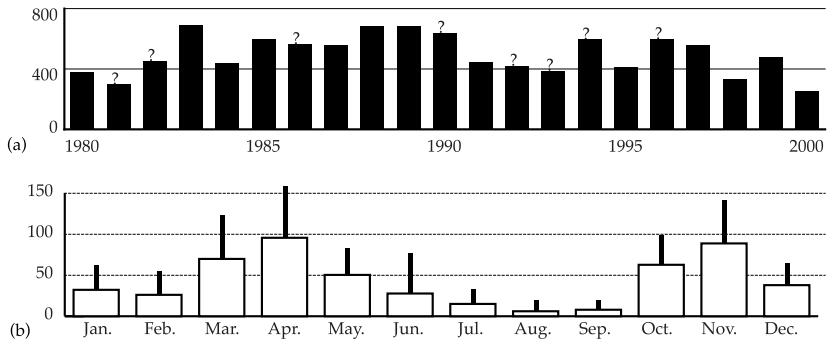

Fig. 2. Precipitation of Baragoi Town, northern Kenya. (a) Annual precipitation fluctuation. (b) Average monthly rainfall with two rainfall maxima in a year. Solid bars show SD. "?" indicates incomplete data, one to 3 months missing.

baboons. They are in some parts dependent on the fruits of riverine forest by observation of the author. Large mammals such as zebras and elephants are not seen and thought to be absent, though in the Maralal mountains, 100 km south of the area of this study, and in southern plains zebras are abundant. Elephants are also present there. This paucity of large mammals may be due to the greater hunting pressures by the Turkana natives than is the case by Samburus in Maralal and other area in El Barta Plain.

The ethnic group of Nachola Village is Turkana. The tribal boundary of Turkana and neighboring Samburu is the main road north-south direction which runs through Baragoi. Although in Turkana District, there is a report of primitive cultivation of sorghum and maize, in Kerio Valley and elsewhere in the south part of the District (Hemming, 1972), in this area, maize and millet cultivation is not continuously done. It has been introduced by a foreign aid organization, but the effect on the vegetation is negligible, together with their activity of forestation. Sisal plantation is also absent. Thus, the anthropogenic effects to the vegetation and flora here is of herding, with less affects of fire wood collection, charcoal making and food gathering. Natural and artificial fire are not observed due to the paucity of grasses. Fires are said to sustain grassy vegetations, known in elsewhere Kenya, such as in Masai Mara and in Serengeti.

The collection and research at the site was made in June, December 2000, February and April 2001, August and September 2002 by the author. These seasons were selected for the greater probability of collecting flowers, fruits and vegetative parts, which are abundant in and after rainfall. These seasons are also suitable for collection of ephemeral plants which grow rapidly after the rainfall and mature immediately, then disappear.

Collection and voucher making method is based on the guideline of the East African Herbarium, National Museums of Kenya (privately distributed) and the guidebook of the Royal Botanic Gardens, Kew (Bridson & Formann, 1998). Habitats and habits of plants collected are also recorded. Ethnobotanical information, vernacular names and traditional usages, were also obtained by interviewing the Turkana residents in the village. Criteria of the interview were based on the study of ethnobotany of neighboring Samburu (Heine *et al*., 1988). The blanks for the vernacular names mean that they were not interviewed. All species are given their local names by informants when they were asked to. Identification of the specimens was done in the Herbarium of the Botany Department, University of

Table 1. BA composition of riverine forest and grassland tree species.

n	BA (m^2) sum	BA per individual	BA per 1m transect	edible	species
riverine forest					
173	24.6724	0.1426	0.017436	Yes	*Acacia tortilis* ssp. *spirocarpa*
20	17.3323	0.8666	0.012249	Yes	*Ficus sycomorus*
4	0.1386	0.0346	0.000098		*Gardenia* sp.
3	0.0941	0.0314	0.000066	Yes	*Ziziphus mucronata*
1	0.0147	0.0147	0.000010	Yes	*Salvadora persica*
1	0.0035	0.0035	0.000002	Yes	*Cissus rotundifolius*
1	0.0018	0.0018	0.000001		*Combretum* sp.
grassland					
14	3.5805	0.2558	0.000402	Yes	*Acacia tortilis* ssp. *spirocarpa*
3	0.2734	0.0911	0.000031	Yes	*Balanites* spp.
8	0.1045	0.0131	0.000012	Yes	*Commiphora* spp.
1	0.0459	0.0459	0.000005		*Acacia mellifera*
1	0.0287	0.0287	0.000003		*Boscia coriacea*
1	0.0199	0.0199	0.000002	Yes	*Salvadora persica*
1	0.0032	0.0032	0.000000		*Adenium obesum*

Transect lengths are 1415m in the riverine forest and 8980m in the grassland compositions. Units are m^2 unless noted. BA per 1m transect is in 1 m length of transect, i.e. $4m^2$.

Nairobi with the specimens stored there. The systematics applied here is of the "Flora of Tropical East Africa", with handy references being the works of Beentje (1994), and Agnew & Agnew (1994). The set of voucher specimens are going to be stored in the Herbarium of Kyoto University (KYO), first duplicate in the East African Herbarium, the National Museums of Kenya, Nairobi, Kenya (EA) the following in the Royal Botanic Gardens, Kew, London (K) and the University of Nairobi, Kenya (NAI). Some specimens will be stored in other herbaria in Japan.

I compared the characteristics of vegetation between riverine forest and hinterland grasslands to evaluate the productivity of the former. The line transect method, which is comprised of several sections (Fig. 1) are employed to know the distinctions of tree size and distribution. These sections are selected to show the characteristics of riverine forest and grasslands (hinterlands), and are aligned along the rivers longitudinally and the others in the plains not parallel to the river or transversely, occasionally across slope or escarpment. The length of each section depends on the geography. The locations of the transect nodes were measured by hand held GPS. All the trees higher than 3 m, occurring within 4 m width of the transect are measured for the Girth of Breast Height (GBH) for calculating their Basal Area (BA), its species and distance from the node of the transect. To estimate the fruit productivity for frugivorous animals including primates, other fruiting species, which are not measured on BA, such as low shrubs, lianas and herbs which are reported edible. *Cissus rotundifolium*, *C. quadrangularis*, *Cordia* spp. and *Grewia* spp., are among the species to be recorded.

In this study, the word "savanna" is avoided, because a precise definition of this word is not settled. Although the Scientific Council for Africa in Yangambi in 1956 agreed to define savanna as follows: "Formations of grasses at least 80 cm high, forming a continuous layer dominating a lower stratum. Usually burnt annually. Leaves of grasses flat, basal and cauline. Woody plants usually present" (Bourière & Hadley, 1983), various authors used this term in their own sense, in which the vegetation of Nachola would be excluded. Instead, to describe vegetation, "forest", "woodland", "grassland" and "desert" are used,

simplified from White (1983). This series of vegetation types is well used in the fields of East African vegetation, and also in paleoanthropology in East Africa, to mention the paleoenvironments of hominids and hominoids. In the classification of Lind & Morrison (1974), Nachola lies in wooded grassland or bushland and thicket, according to their map or coordinations, and considering the coverage of trees, this is semi-desert grassland. As for White (1983), this area is in the "Somali-Masai centre of endemism". As for the type of vegetation, it is classified into "Somali-Masai *Acacia-Commiphora* deciduous bushland and thicket" or "Somali-Masai semi-desert grassland and shrubland", or the transitional zone between the two.

RESULTS

One hundred sixty-two species of 46 families are recorded (Appendix). On species basis, the largest family is Acanthaceae, followed by Euphorbiaceae, Amaranthaceae, Capparaceae, Compositae, Cucurbitaceae and Gramineae. Only one species of Pteridophyta (fern) appears here, *Actincopteris radiata*, which grows in the gaps of rocks in the rocky hills. Its biomass is small. Gymnosperms do not appear here. It is because of the low altitude of this area. The highest altitude of this area is at the top of rocky hill shown in Fig. 3b, called locally Soit Ongiron or Mlima Punda (Donkey Hill), ca. 1280 m alt., read from the topographic map. It is far lower than the lower limit of African Montane forest which is characterized by the occurrence of Gymnosperms such as *Podocarpus* and *Juniperus* (White, 1984). All species in the table except one Pteridophyte are Angiosperm. The lack of mountainous species such as *Hypericum* and *Erica* can be explained the same as with Gymnosperm. One hundred forty-two species of Dicotyledon and 18 of Monocotyledon are seen here.

The landscape here is divided into two broad types according to the tree density and composition: riverine forest along the seasonal rivers (e.g. Baragoi River and Nachola River) dominated by *Ficus sycomorus* and *Acacia tortilis* ssp. *spirocarpa* (Fig 3a), and open vegetation or "grassland" in the comparatively flat hinterland or the plains (Fig 3b, c). The term "riverine forest" and "grassland" are used afterwards, though the latter is dominated by Labiatae dwarf shrub (*Leucas* spp.). Application of the word "grass" may bring confusion with the actual vegetation, pointed out elsewhere (White, 1984), however, here they are applied according to the classification of White (1984) and Greenway (1973) based on the coverage of tree layer.

Typical pattern of tree occurrences and Basal Area Compositions of species are shown in Figs. 4 and 5 both along the rivers and in hinterlands. The numbers and BA sums of riverine and hinterland trees are given in Table 1. Tree crowns along the rivers are continuous. This vegetation is well suited to the definition of forest by White (1983). He defined as "Forest is a continuous stand of trees. The canopy varies in height from 10 m to 50 m or more". Although he describes the "riverine forest" in this region quite briefly, it is well-settled riverine forest in a semi arid area. Lianas are scarce but present. *Combretum* spp., *Cissus rotundifolium*, and *Dolichos* spp. are found as climbers. Shrub layers are present unless the areas where the surfaces are heavily occupied by humans and livestock. Major species of this layer are *Acalypha* spp. *Grewia* spp. *Cordia* spp. Acanthaceae spp.

In the hinterland, in contrast, trees are much more sparse. As seen in Figs. 4 and 5, trees

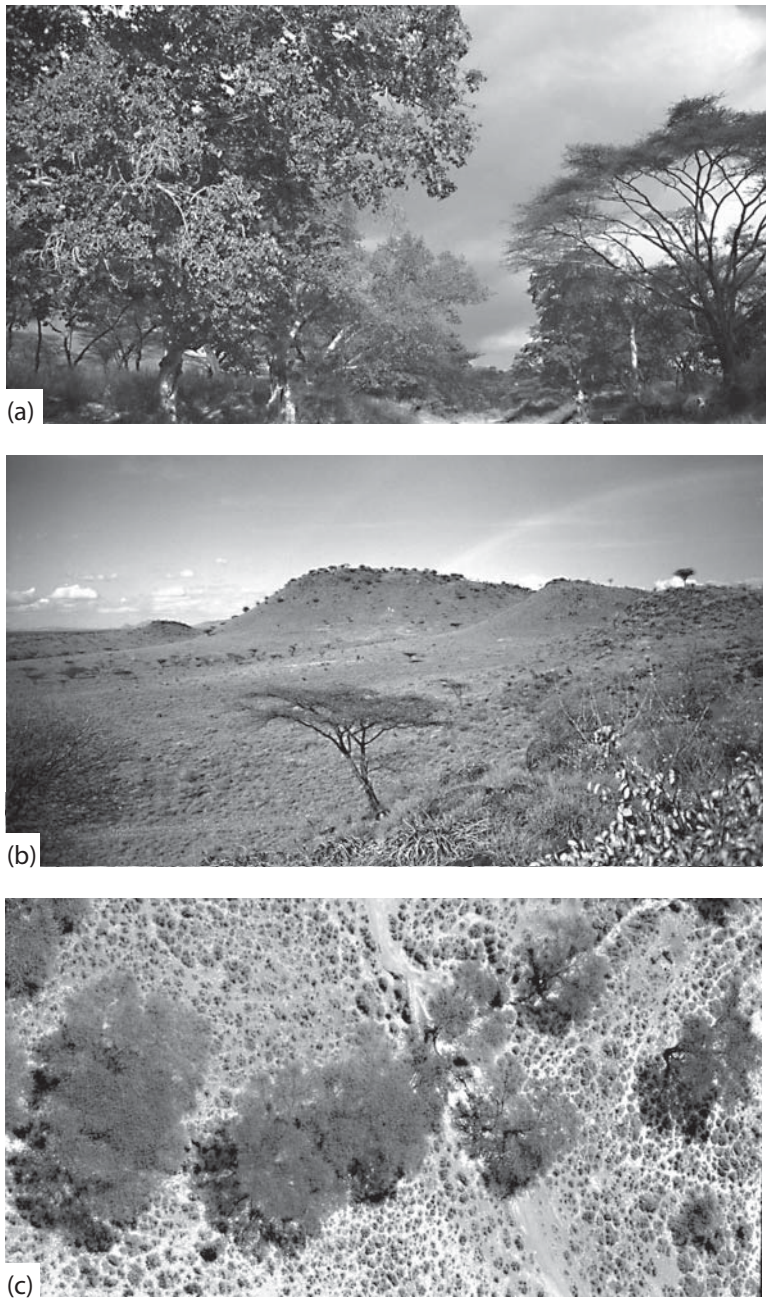

Fig. 3. Typical landscapes of Nachola. (a) Riverine vegetation in the Baragoi River. Front left is *Ficus sycomorus*, right is *Acacia tortilis* ssp. *spirocarpa*. (b) Open grassland including highest peak of this area, Soit Ongiron. Ground cover is *Leucas* spp., standing tree is *Acacia tortilis*. (c) Aerial view of grassland including *A. tortilis* along a small tributary.

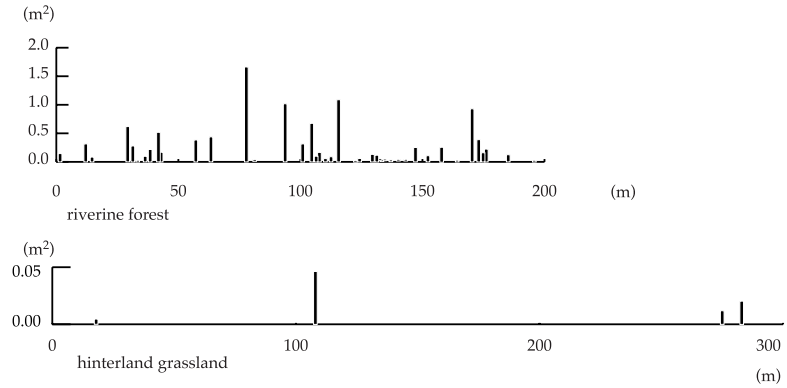

Fig. 4. Tree sizes (given in basal area: m^2) in typical transects in riverine forest and in grassland. Note that the vertical scale of riverine forest is 10 times larger.

are standing isolated. *Acacia* spp., *Balanites* spp. and *Commiphora* spp. are scattered among low ground covering. Ground cover is comprised of dwarf shrub, such as *Leucas* spp. In the plains, "grassland" is the typical landscape. Here shrubs or grass layer, *Leucas* spp. and Malvaceae spp. are the dominants. They are less than 1 m high, commonly 50 cm to 70 cm. There are many dome-shaped bushes found, 1 to 2 m high, several metres diameter. These bushes comprise shrubs of leafless, succulent branches of 1 to 1.5 cm diameter, 5 to 30 cm length. Species of this type are of Compositae sp., Asclepiadaceae sp. or *Cissus quadrangularis* are similar in their shape or habit, but distinct in taxonomy. Edible small plants (e.g. Cucurbitaceae, *Grewia* spp. & *Ipomoea* spp.) are not recorded in this line transect method, in spite of the listed species are present in this area in Appendix.

Vegetation of succulent dominant is found scattered in western part of this study, to mention *Euphorbia* spp., *Caralluma* spp., and *Sansevieria robusta*. *Euphorbia* sp. is the dominant in western part of the area,

Barkham & Rainy (1976), and Hemming (1972) reported that there are some saline tolerant species growing in Northern Kenya, but this study does not show these physiognomic species. For example, doum palm, *Hyphaene* spp. and the grass *Sporoborus consimilis* occur in the Suguta valley. Hemming (1974) observed extensive distribution of this vegetation in the Suguta Valley and Kerio Valley. The area of this study does not have such strongly saline soil.

In order to estimate the resource richness for humans and apes the flora reported here is analyzed in terms of the food utilization by native groups of northern Kenya, shown in Appendix 1 also. Dorobo is a hunter-gatherer group ranging widely from northern Kenya to Tanzania. On plant utilizations, Suiei Dorobo, a subgroup of Dorobo, is the nearest reported group from the site of this study. Their range is in Mathew's Range in Northern Kenya, 80 km southeast of Baragoi. Ichikawa (1980) reported their plant foods. Another group Samburu is a pastoralist living next to the Turkana. Heine *et al*. (1986) compiled their plant utilization on food, together with medicinal, material use. Of these studies, edible genera are shown in Appendix.

This listed food utilization by humans is too incomplete to know the abundance of plant food resources in this semi arid land. There are reasons for this: plants were not all presented to the informants in Nachola. Turkanas of the village of this study are comparatively little

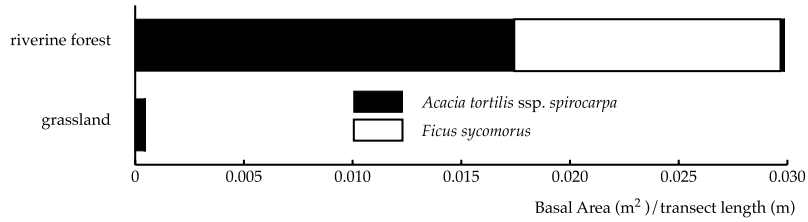

Fig. 5. Species composition in basal area from line transects. The horizontal bars represent basal area per transect length. Grassland has small biomass of trees. Riverine forest is mostly comprised of *Acacia tortilis* and *Ficus sycomorus*. Other species are not contributing significantly to the forest.

dependent on the plants. Twenty-eight species of this flora are reported to be edible by Suiei Dorobos, only 7 species by Turkanas, 46 by Samburus. These figures can not be compared directly due to the difference of each research plan. However, a rough idea of the richness of human plant food can be obtained.

Table 1 shows also the abundance of tree species of edible fruits. From the sum and individual BAs, *Ficus sycomorus* and *Acacia tortilis* in riverine forest are the major fruit producers. An observation suggests that of the two species, *F. sycomorus* is the most abundant in fruit supply for frugivorous animals such as primates. The two dominant species share the forest along the river, although they have quite distinct phenology. Makishima (2005) describes the asynchronous phenology of *F. sycomorus*, which produces fruits all the year. In contrast, *A. tortilis* has synchronized flowering period and thus fruit season. In August 2002 the species had neither flowers nor fruits, but in April 2001 fruits or pods of this *A. tortilis* were abundant. Amounts of fruits that *A. tortilis* bear are in certain periods comparable with that of *F. sycomorus* on the basis of preliminary observations. Other species such as *A. mellifera* and *Salvadora persica* are far less in BA, and fruit production is far more insignificant.

DISCUSSION

According to White (1984) and Itani (2002), The vegetation of this study is called “grassland”. They also point out the low grass (Gramineae) biomass. Actually grass biomass is poor. The major part is made from Labiatae and other species of dwarf shrubs. Possible niches for ephemeral grass is limited in this “grassland”, the surface is covered already by these shrubs. Lind & Morrison (1974) note that ephemeral grasses are the dominant, sometimes exceeding to 90 % of the cover. It is apparent, however, that the available ground for ephemerals is less than 50 % here. It is true that the impact of livestock grazing is huge, but it is not probable that the author has failed to find annuals and ephemerals because animals had thoroughly eaten the grasses grown there. Compared to the table of Lind & Morrison (1974), which has 53 genera listed, the numbers of grass species in Nachola are much lower, only 6 are recorded. This must be close to the true representation of the flora here, even though the identification of grasses was difficult due to their lack of identifiable characters when they are sterile.

Severe fluctuation in rainfall is one of the limiting factors for this type of vegetation. Vegetational change caused by changes in the water supply is reported by Barkham &

Rainy (1976) in Samburu Isiolo Game Reserve. They observe forests of young adolescent trees of *Acacia* spp. and those of contrasting dying trees. Here no such result or observation is obtained, but there is a possibility of such a phenomenon.

This area is considered as a modern proxy of early hominid habitat from the annual rainfall (520 mm per year) and vegetation patchiness, though livestock grazing should be taken into account. As food resource, it could be said that the abundant production of *Ficus sycomorus* is worth considering, from the point of view that the trees of this species are large. In addition to supplies of *A. tortilis* and *Ziziphus mucronata* in the riverine forest, *F. sycomorus* is the key species of fruit supply of this forest (Makishima, 2005).

Other fruit producing tree species in this forest, such as leguminous *Acacia* spp. (e.g. *A. tortilis* ssp. *spirocarpa*, *A. mellifera*), *Delonix* spp. and others are worth mentioning. Leguminous pods (i.e. fruits of Leguminosae) and seeds are richer in protein (Kagawa, 1986) than figs. Commonly legume pods are considered as an important source of protein for frugivorous or herbivorous animals. *A. tortilis* ssp. *spirocarpa* produces considerable amount of fruit (i.e. pods) in certain seasons, not surveyed in this study. However, the phenology of the species synchronizes with trees in the species, such as *Z. mucronata*. During the period of this study (August - September 2002), flowers and fruits of this species were never seen. The pods may be a staple for frugivorous or folivorous animals in certain seasons, but it can not be a fallback resource.

Fruits of *Z. mucronata* and *Salvadora persica* are more scarce but could be one of the important seasonal foods for frugivorous primates. Fruits of *Z. mucronata* have fruit pulp, exo- and endocarp. Its phenology is synchronous between individuals. Thus, its fruits are only available for short periods. *S. persica* bears fruits for long periods of the year, but their size is quite small (1 - 2 mm in diameter), and they ripen asynchronous in the inflorescence, or the fruits cluster. Thus, the collecting of *S. persica* fruits is quite labour intensive, and they are thus preferred less than large fruits (Sept, 1984).

Other types of plant foods are not surveyed in this study, such as tuberous roots of *Ipomoea* spp., matured and young leaves of Leguminosae and other species, young shoots of Monocotyledons such as bamboo shoots (though it is absent here), pith and barks, and many other types of plant parts. Some of them may yield considerable amounts of edible matter in certain seasons, and they are subject of further study.

The Terrestrial Herbaceous Vegetation (THV) which is often observed as a staple food for chimpanzees and gorillas (Idani *et al*., 1994; Moutsamboté *et al*., 1994; Yumoto *et al*., 1994), might be available sparsely in their season. The taxa of possible THV resource in Nachola are Commelinaceae species but scarcely found. Zingiberaceae and Maranthaceae, which are major components of THV, are not found. The productivity of such vegetation is worth surveying.

Quantitative analysis of plant food production should be done to discuss the capacity of herbivorous or frugivorous animals such as primates. Semi arid land vegetation is thought to be poor in biomass and diversity, thus less work has done in this subject. Possibility of early hominid habitat should be discussed on the basis of modern affinities for food availability.

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REFERENCES

Agnew, A.D.Q. & S. Agnew 1994. *Upland Kenya Wild Flowers - A Flora of the Ferns and Herbaceous Flowering Plants of Upland Kenya (Second Edition)*. East Africa Natural History Society, Nairobi.

Aubrville, A., P. Duvingeaud, A.C. Hoyle, R.W.J. Keay, F.A. Mendoça & R.E.G. Pichi-Sermolli 1958. *Vegetation map of Africa*. UNESCO, Paris.

Barkham, J.P. & M.E. Rainy 1976. The vegetation of the Samburu-Isiolo Game Reserve. *East African Wildlife Journal*, 14: 297-329.

Beentje, H.J. 1994. *Kenya, Trees, Shrubs and Lianas*. National Museums of Kenya, Nairobi.

Bonnefille, R. 1984. Palynological research at Olduvai Gorge. *National Geographic Society Research Reports*, 17: 227-243.

Bridson, D. & L. Forman 1998. *The Herbarium Handbook (Third Edition)*. Royal Botanic Garden, Kew, London.

Bourlière, F. & M. Hadley 1983. Present-day savannas: an overview. In (F. Bourlière, ed.) *Tropical Savannas (Ecosystems of the World 13)*, pp. 1-17. Elsevier, Amsterdam.

Brenan, J.P.M. 1959. *Mimosoideae (Flora of tropical East Africa Leguminosae Subfamily, part 1*). Crown Agents for Oversea Governments and Administrations, London.

Chesters, K.I.M. 1957. The Miocene flora of Rusinga Island, Lake Victoria, Kenya. *Palaeonthographica Abteilung B, Paläeophytologie*, 101: 30-71.

Coppens, Y. 1994. East Side Story: the origin of humankind. *Scientific American*, 270: 88-95.

Gillett, J.B., R.M. Polhill & B. Verdcourt 1971. *Papilionoideae (Flora of tropical East Africa. Leguminosae; Subfamily, Part. 3-4)*. Crown Agents for Oversea Governments and Administrations.

Greenway, P.J. 1973. A classification of the vegetation of East Africa. *Kirkia: Journal of the Federal Herbarium, Salisbury, Rhodesia and Nyasaland*, 9: 1-68 with small scale vegetation maps.

Hedberg, O. 1969. Taxonomic and ecological studies on the Afroalpine flora of Mt. Kenya. *Hochgebirksforschung*, 1: 174-94.

Heine, B., I. Heine & C. König 1988. *Plants of the Samburu (Kenya). (Plant Concept and Plant Use: An Ethnobotanical Survey of the Seni-Arid and Arid Lands of East Africa. Part 5)*. Verlag Breitenbach Publishers, Saarbrücken, Fort Lauderdale.

Hemming, 1972. The South Turkana Expedition. Scientific papers VIII. The ecology of South Turkana: a reconnaissance classification. *The Geographical Journal*, 138: 15-40.

Ichikawa, M. 1980. The utilization of wild plants by the Suiei Dorobo in Northern Kenya. *The Journal of the Anthropological Society of Nippon*, 88: 25-48.

Idani, G., S. Kuroda, T. Kano & R. Asato 1994. Flora and vegetation of Wamba Forest, Central Zaire with reference to Bonobo (*Pan paniscus*) foods. *Tropics*, 3: 309-332.

Itani, J. & H. Terashima 2001. African vegetation map: a proposal (in Japanese). *Humanities and Sciences*, 15: 15-18 with coloured vegetation map.

Itani, J. 2001. Asking the site of human origin (in Japanese). *Humanities and Sciences*, 15: 1-14.

——— 2002. Rethinking African Vegetation (in Japanese). *Journal of African Studies*, 60: 1-33.

Jacobs, B.F. & D.A. Winkler 1992. Taphonomy of a middle Miocene autochtonous forest assemblage, Ngorora Formation, central Kenya. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 99: 31-40.

Kappelman, J. 1991. The paleoenvironment of *Kenyapithecus* at Fort Ternan. *Journal of Human Evolution*, 21: 95-129.

Kingston, J.D., B.F. Jacobs, A. Hill & A. Deino 2002. Stratigraphy, age and environments of the late Miocene Mpesida Beds, Tugen Hills, Kenya. *Journal of Human Evolution*, 42: 95-116.

Kinnaird, M.F. 1992. Phenology of flowering and fruiting of an East African riverine forest ecosystem. *Biotropica*, 24: 187-194.

Lind, E.M. & M.E.S. Morrison 1974. *East African Vegetation*. Longman, London.

Macho, G.A., M.G. Leakey, D.K. Williamson & Y. Jiang 2003. Palaeoenvironmental rconstruction: evidence for seasonality at Allia bay, Kenya at 3.9 million years. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 199: 17-30.

Makishima, H. 2005. *Ficus sycomorus* fruit production in a semi arid land in northern Kenya: implications for understanding a possible food resource of early hominids. *African Study Monographs Supplimentary Issue*, 32: 81-88.

Pickford, 1987. Fort Ternan (Kenya) paleoecology. *Journal of Human Evolution*, 16: 305-309.

Pickford, M. & B. Senut 2001. The geological and faunal context of Late Miocene hominid remains from Lukeino, Kenya. *Comptes Rendus de l'Académie des Sciences, Series IIA, Earth and Planetary Science*, 332: 145-152.

Retallack, G.J., E.A. Bestland & D.P. Dugas 1995. Miocene paleosols and habitats of *Proconsul* on Rusinga Island, Kenya. *Journal of Human Evolution*, 29: 53-91.

Sept, J.M. 1984. *Plants and Early Hominids in Africa: a Study of Vegetation in Situations Comparable to Early Archaeological Site Locations*. Ph. D. Dissertation, University of California, Berkeley, Berkeley.

——— 1986. Plant foods and early hominisa at Site FxJj 50, Koobi Fora, Kenya. *Journal of Human Evolution*, 15: 751-770.

Turill, W.B. & E. Milne-Redhead (1952-1958), C.E. Hubbard & E. Milne-Redhead (1958-1966), E. Milne-Redhead & R.M. Polhill (1966-1972) and R.M. Polhill (1972-present) eds. 1952-. *Flora of Tropical East Africa*. Crown Agents, London.

Vincens, A. 1987. Environments botanique et climatique des hominides de l'Est Turkana, Kenya, entre 2,0 et 1,4 millions d'anneés: Apport de la palynologie. In (J.A. Coetzee, ed.) *Palaeoecology of Africa and the Surrounding Islands*, pp. 257-267. A. A. Balkema, Rotteldam.

Ward, C.V., M.G. Leakey & A. Walker 2001. Morphology of *Australopithecus anamensis* from Kanapoi and Allia Bay, Kenya. *Journal of Human Evolution*, 41: 255-368.

White, F. 1983. *The Vegetation of Africa - A Discriptive Memoir to Accompany the Unesco/AETFAT/ UNSO Vegetation Map of Africa*. UNESCO, Paris.

Wynn, J.G. 2000. Paleosols, stable carbon isotopes, and paleoenvironmental interpretation of Kanapoi, Northern Kenya. *Journal of Human Evolution*, 39: 411-432.

——— 2004. Influence of Plio-Pleistocene aridification on human evolution: Evidence from paleosols of the Turkana Basin, Kenya. *American Journal of Physical Anthropology*, 123: 106-118.

Wynn, J.G. & G.J. Retallack 2001. Paleoenvironmental reconstruction of middle Miocene paleosols bearing *Kenyapithecus*, Nyakach Formation, southwestern Kenya. *Journal of Human Evolution*, 40: 263-288.

Yumoto, T., J. Yamagiwa, N. Mwanza & T. Maruhashi 1994. List of plant species in Kahuzi-Biega National Park, Zaire. *Tropics*, 3: 295-308.

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Appendix. Taxonomical and ethnobotanical list of plants found in Nachola, Northern Kenya.

Family (subfamily), and higher taxa species	Specimen number(s)	Vernacular name(s)	Food use
PTERIDOPHYTA			
Adianthaceae			
Actincopteris radiata (Sw.) Link	0103044	lorukopus	D
ANGIOSPERMAE			
DICOTYLEDONAE			
Acanthaceae			
Acanthaceae sp.	0208013		
Barleria acanthoides Vahl	0101122		
Barleria eranthemoides C.B.Cl.	0103101	logolito	
Duosperma eremophilum (Milne-Redh.) Brummitt	0103147	emekuya	
Justicia heterocarpa T. Anders.	0101091		
Justicia odora (Forsslk.) Vahl	0103010		
Lepidagathis scariosa Ness	0103011		
Ruellia patula Jacq.	0103041	lokoros	
Aizoaceae			
Gisekia pharmaceoides L.	0101102		
Mollugo cerviana (L.) Ser.	0101028		
Zaleya pentandra (L.) Jeffrey	0103146	elete	
Amaranthaceae			
Achyranthes aspera L.	0103137	lokuchin	
Aerva javanica (Burm.f.) Schultes	0103170	ekuanga	
Dasyphaera prostrata (Gilg) Cavaco	0101055		
Sericocomopsis pallida Schinz	0006060		
Apocynaceae			
Adenium obesum (Forssk.) Roem. & Schult.	0006051		
Asclepiadaceae			
Calotropis procera (Ait.) Ait. f.	0208081		
Caralluma acutangula (Decne.) N.E.Br.	0006018		(D) (S)
Caralluma arachnoidea (Bally) M. Gilbertb.	0101116 0208074		(D) (S)
Ceropegia ballyana Bullock	0103025	lokurumoo	(D)
Dregea stelostogma (K.Schum.) Bullock	0006063		
Edithcolea grandis N.E.Br.	0103026	lokodosio	
Gomphocarpus fruticosa (L.) Ait. f.	0208003		
Sarcostemma andogense Hiern.	0103005	elila	
Balanitaceae			
Balanites glabra Mildbr. & Schlecht.	0103176	elamach	T (D) (S)
Balanites pedicellaris Mildbr. & Schlecht.	0103176 0208012		(D) (S)
Boraginaceae			
Cordia monoica Roxb.	0103107	lobitwosin	T (D) (S)
Cordia quercifolia Klotzsch	0006001		(D) (S)
Cordia sinensis Lam.	0208001		S
Heliotropium longiflorum (A. DC.) Jaub. & Spach.	0101043		
Heliotropium rariflorum Stocks	0103222	emunyumunyu	
Burseraceae			
Boswellia neglecta S. Moore	0006014 0103223		(S)
Commiphora africana (A.Rich) Engl.	0103177	ekadeli	D S
Commiphora edulis (Kl.) Engl. ssp. *boiviniana* (Engl.) Gillet	0006052		(D)
Commiphora ellenbeckii Engl.	0006016		(D)
Commiphora kua (J.F.Royle) Vollesen	0101110		(D)
Commiphora sp.	0103019	ekadeli	(D)
Capparaceae			
Boscia angustifolia A. Rich	0101053		
Boscia coriacea Pax	0103226 0208014	edung	T S
Cadaba farinosa Forssk.	0103013	ereng	S
Cleome angustifolia Forsk.	0103261	echokokile	(S)
Cleome brachycarpa Vahl ex DC.	0103259	lonyangaworet	(S)

(Continued)

Family (subfamily), and higher taxa species	Specimen number(s)	Vernacular name(s)	Food use
Maerua angolensis DC.	0006003		(D) (S)
Maerua decumbens (Brongen.) De Wolf	0006011		(D) (S)
Combretaceae			
Combretum constrictum (Benth.) Laws.	0101108		(S)
Compositae			
Aspilia pluriseta Schweinf.	0103102	edomboro	(S)
Geigeria acaulis Oliv. & Hiern	0103003		
Gutenbergia boranensis (S.Moore) M.Gilbert	0103012		
Helichrysum forskahlii (J.F.Gmel) Hillard & Brutt	0103042	lopoe	
Kleinia squarrosa Cuf.	0101112		(S)
Launaea hafunensis Chiov.	0101081		
Vernonia cinerascens Sch.Bip.	0101098		
Convolvulaceae			
Evolvulus alsinoides (l.) L. Plate	0103030	nakirirakiragio	
	0104062		
Hildebrandtia obcordata S.Moore	0103161	ecekeribo	
Hildebrandtia sepalosa Rendle	0101048		
Ipomoea donaldsoni Rendle	0103165	ecekeribo	(D) (S)
	0103227		
Ipomoea kituiensis Vatke	0103115	ekuaki	(D) (S)
Ipomoea obscura (L.) Ker Gawl.	0104065		(D) (S)
Ipomoea spathulata Hall. f.	0006062		(D) (S)
Kalanchoe lanceolata Pers.	0103014	ekacumucumu	(S)
	0101047		
Cruciferae			
Farsetia stenoptera Hochst.	0101004		
	0208051		
Cucurbitaceae			
Cephalopentandra ecirrhosa (Cogn.) C.Jeffrey	0103136	lokareso	
Corallocarpus epigaeus Benth. & Hook.f.	0101096		
Cucumis dipsaceus Spach	0101050		(S)
Cucumis figarei Delile	0208501		(S)
Kedrostis hirtella Cogn.	0103113	ecukut	
Lagenaria sp.	0104051		(S)
Momordica rostrata Zimmermann	0103154	elagama	
Pergularia daemia (Forsk.) Chiov.	0103110	amartoit	
Euphorbiaceae			
Acalypha fruticosa Forsk.	0101038		
	0208033		
Acalypha indica L.	0101072		
Croton menyharthii Pax	0101030		
Croton somalensis Vatke & Pax	0103216	lokirdangae	
Croton sp.	0103166	ekiridangoe	
Euphorbia sp. cf. *bussei*	0103009	nanger	
Euphorbia sp.	0103219	lotou	
Euphorbia sp. cf. *gossypina* Pax.	0101093		
Jatropha ellenbeckii Pax	0006012	lotou	
	0103159		
Ricinus communis L.	0103148	ebung	
	0104002		
Labiatae			
Duosperma eremophilum (Milne-Redhead) Brummitt	0208034		
Leucas glabrata (Vahr) R. Br.	0101080		(S)
Leucas jamensii Bak.	0103160	eur loese	(S)
Orthosiphon somalensis Vatke	0103043	lomesekin	
Plectranthus ignarius (Schweinf.) Agnew	0103221	elila	
Lotanthaceae			
Plicosepalus curviflorus Van Tiegh.	0101120		
Lythraceae			
Lawsonia inermis L.	0208501	esajeit	
	0101031		
	0103171		

(Continued)

Family (subfamily), and higher taxa species	Specimen number(s)	Vernacular name(s)	Food use
Malvaceae			
Abutilon fruticosum Guill. & Perr.	0103162	lomesekin	
Abutilon hirsutum (Lam.) Sweet	0208021		
Abutilon mauritianum (Jacq.) Medik.	0103123	asulubeit	
Pavonia patens (Andr.) Chiov.	0101092		
Moraceae			
Ficus sycomorus L.	0103144 0104057 0104057	echoke (fruit: ngachokio)	T D S
Moringaceae			
Moringa sp.	0006065		
Nyctaginaceae			
Boerhavia erecta L.	0101100		
Commicarpus stellatus (Wight) Berhaut	0103004 0103004	ekajimait	
Leguminosae			
Caesalpinioideae			
Delonix elata (L.) Gambe	0103173	ekurkanait	T S
Parkinsonia aculeata L.	0101111		
Mimosoideae			
Acacia elatior Brenan	0101046		
Acacia etbaica Schweinf.	0101052		
Acacia mellifera (Vahl) Benth.	0208032		
Acacia nubica Benth.	0006002 0208072		
Acacia reficiens Wawra	0103215	eregae	D S
Acacia senegal (L.) Willd.	0006009		D S
Acacia tortilis (Forssk.) Hayne ssp. *spirocarpa* (A. Rich.) Brenan	0103002	ewoi	T D S
Papilionoideae			
Dolichos oliveri Schweinf.	0103153 0103153	egilae	
Indigofera cf. *trita* L. f.	0101074		
Indigofera spinosa Forsk.	0101017		S
Lonchocarpus bussei Harms	0103168	lourelori	
Ormocarpum kirkii S. Moore	0103001	locekerobo	(S)
Ormocarpum trachycarpum (Taub.) Harms	0101019		(S)
Rhynchosia sp.	0103109	kamaret	
Rhynchosia malacophylla Boj.	0103212	emaret	
Passißoraceae			
Adenia venenata Forsk.	0101115		
Pedaliaceae			
Pedaliaceae sp.	0208551		
Polygalaceae			
Polygala erioptera DC.	0103208	amartoit	
Portulacaceae			
Portulaca oleracea L.	0104006	ekalelete	
Portulaca parensis Poelln.	0103032	lokosupoo	
Portulaca quadrifida L.	0101114		
Talinum portulacifolium Aschers. ex Schweinf.	0103132	lokurumo	D
Rhamnaceae			
Ziziphus mucronata Willd. ssp. *mucronata*	0101011		S
Rubiaceae			
Gardenia sp.	0103111	ekoree	
Kohautia caespitosa Schnizl.	0101106		
Kohautia coccinea Royle	0103207	kilekilek	
Pentanisia ouranogyne S.Moore	0103172	lolijok	
Salvadoraceae			
Salvadora persica L.	0006053		D S
Scrophulariaceae			
Pseudosopubia hildebrandtii Engl.	0103209	lokoporae	

(Continued)

Family (subfamily), and higher taxa species	Specimen number(s)	Vernacular name(s)	Food use
Solanaceae			
Datura ?*stramonium* L.	0208002		
	0208041		
Datura metel L.?	0208042		
Lycium eurapaeum L.	0101097		
	0101007		
Solanum coagulans (= *S. dubium*) Forsk.	0208061		(D) (S)
Solanum incanum L.	0208073		(D) (S)
Withania sommifera (L.) Dunal	0208071		
Sterculiaceae			
Sterculia africana (Lour.) Fiori	0208082		T S
Tiliaceae			
Grewia cf. *tenax* (Forssk.) Fiori	0101077		D S
Grewia bicolor Juss.	0101027		D S
Grewia sp.	0101103		(D) (S)
Grewia lilacina K.Schum.	0006017		D (S)
Grewia villosa Willd.	0103127A		D (S)
Corchorus trilocularis L.	0103217	kilekilek	
Verbenaceae			
Chascanum laetum Walpern	0103218	natupan	
Lippia carviodora Meikle	0103141		(S)
Vitaceae			
Cissus quadrangularis L.	0103008	egis	(S)
Cissus rotundifolium ?	0208551		
Zygophyllaceae			
Tribulus terrestris L.	0103104	esugum	
MONOCOTYLEDONAE			
Aloaceae			
Aloe sp.1	0103129	locucuka	(S)
Aloe sp.2	0103251	lokutoma	(S)
Asparagaceae			
Asparagus falcatus L.	0103220	esikariliru	(D) (S)
Commelinaceae			
Commelina reptans Brenan	0104063		
Cyperaceae			
Cyperaceae sp.1	0104022	ekeriou	
Cyperaceae sp.2	0104030	ekeriou lo areit	
Dracaenaceae			
Sansevieria conspicua N.E.Brown ?	0103213		
Sansevieria robusta N.E.Brown	0103108	abukut	
Gramineae			
Aristida mirabilis ?	0208052		
Chloris virgata Sw.	0103120	ejao	
Enneapogon cenchroides (Licht.ex Roem. & Schult.) C.F.Hubbard	0103037	esunengor	
Latipes senegalensis Kunth	0103258	esudokomon	
Setaria verticillata (L.) P. Beauv.	0103121		
Sporobolus spicatus Kunth	0006059		
Tetrapogon cenchriformis (A. Rich.) W. D. Clayton	0208015		
Tetrapogon villosus Desf.	0103035	engolo	
Lililaceae			
Olnithogalum sp.	0208016		
Orchidaceae			
Ansellia africana Lindley ?	0101087C		

Food; T: Turkana (this study), S: Samburu (Heine *et al*. 1988), D: Suiei Dorobo (Ichikawa, 1980), in parentheses: different species of same genus.