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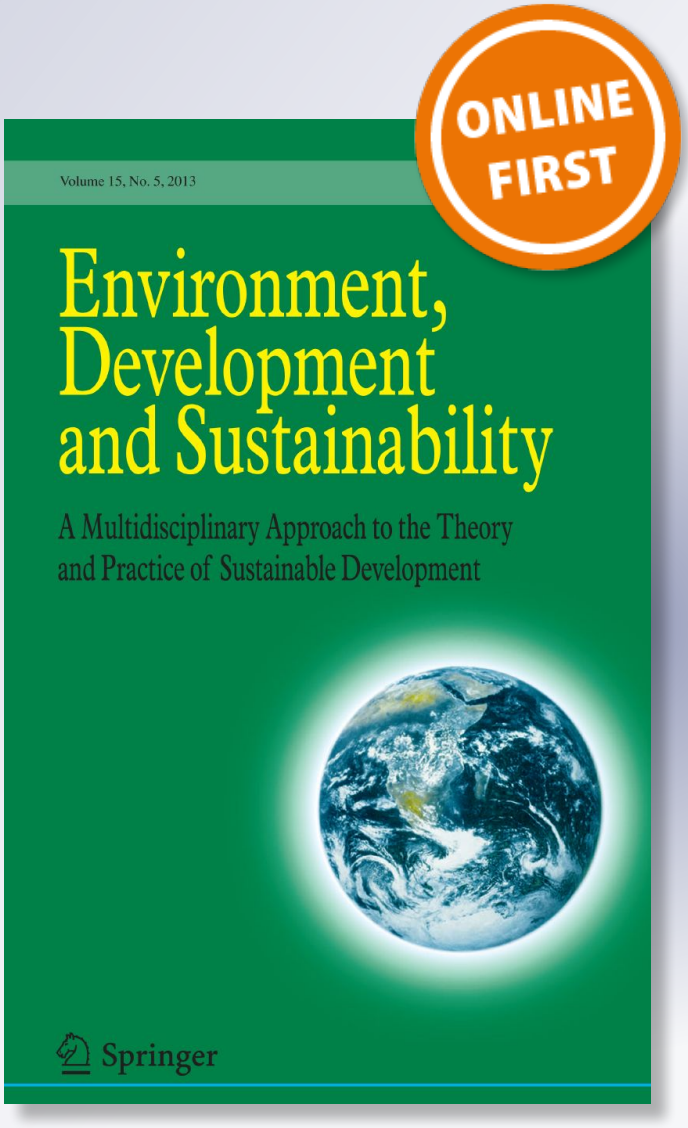

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Ethnomedicinal plants of the Loita Maasai of Kenya

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Abstract
Traditional medicinal plants play a central role in primary health care in most African communities, including that of the Maasai. Unfortunately, the local Maasai knowledge is under enormous pressure from introduction of agriculture, population growth, and climate change—all of which affect availability and regeneration of natural resources and ecosystem services which are accompanied by erosion of traditional knowledge. Loss of medicinal plants and the knowledge related to them would have devastating effects on the Maasai community. Therefore, it is important to document the plants and the traditional knowledge related to their use, and conservation and management. We interviewed 31 informants who were especially knowledgeable about medicinal plants. Based on these interviews, we document 62 plant species that the Loita Maasai use as medicine, and we describe the parts of the plant that are used, the methods of preparation, and how they are used. We rank them according to their importance to the people and discuss the management practices developed for these resources, and we evaluate the conservation status.

Keywords Conservation · Local knowledge · Management · Primary health care

1 Introduction

Medicinal plants are important to human health and survival. Globally, there are about 391,000 described plant species, of which over 31,000 (8%) have a documented use and almost 18,000 (5%) have medicinal use (Kew.org 2016). Approximately three billion

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people in the developing world depend on medicinal plants for health and spiritual purposes (Kala 2000), and four out of five Africans use traditional medicinal plants for their primary healthcare needs (World Health Organization 2010). The very common use of medicinal plants in developing countries is related to the fact that they are efficient in treatments of many diseases, they are easily available compared to conventional medicine, and they are strongly associated with traditional beliefs (Nault and Gagnon 1993; Kisangau et al. 2007). In Kenya, over 70% of the rural population use medicinal plants to fight illnesses (Odera 1997).

The Maasai are traditionally nomadic pastoralists who occupy the southern part of Kenya. They depend on livestock production and cattle are their main source of wealth (Muchiru et al. 2009). Traditional medicinal plant knowledge is deeply rooted in the Maasai culture, and medicinal plants constitute an ecosystem service that is important for the Maasai's close relationship with nature and dependence on the surrounding environment for survival (Kiringe 2006; Bussmann et al. 2006). The use of traditional medicinal plants is best illustrated by their occasional forest retreats at *Orpul*, (a men's camp) to reenergize, refresh, and to boost their immune system. During the retreat, which can last up to a month, cows and goats are slaughtered and medicinal plants collected for soup preparation (Burford et al. 2001). The soup is prepared by boiling the plants together with meat for good health. In addition, the Maasai use plants in ceremonies such as traditional blessings, rites of passage, and circumcision. It is through experience and observation that the Maasai have developed an intrinsic understanding of local plant species that supports the community's holistic system for health care, with all its physical, psychological, spiritual, and social dimensions (Burford et al. 2001). The Maasai use medicinal plants to treat both human and animal diseases (Ole-Miaron 2003), and one medicinal plant species can be used to treat more than one disorder. The most commonly used parts of the plants are the roots, bark, and leaves (Kokwaro 2009). The method of preparation also depends on which parts are used, as well as the health condition being treated. Traditional practices ensure that the Maasai heritage is constantly preserved and respected. Maasai knowledge transmission takes place orally between generations and along gender lines. Girls acquire new knowledge from their mothers and grandmothers mostly during household activities while boys learn from their fathers and grandfathers as they look after livestock in the fields (Maundu et al. 2001).

Unfortunately, the local Maasai knowledge is under enormous pressure from a variety of practices and trends that are destructive to traditional knowledge, such as introduction of agriculture, modernization, population growth, and climate change (Kiringe 2006). All of these affect availability and regeneration of natural resources and ecosystem services. Another factor that affects this knowledge includes urbanization, which removes people from rural life in close contact with nature, to lives in cities which are more removed from nature (Kiringe 2005). Urbanization affects cultural knowledge as the younger generations move away from rural areas in search of jobs and a different lifestyle (Akerele et al. 1991; Kiringe 2005). Finally, local knowledge is affected by the increasing amount of time spent in school by children acquiring a formal education. The Maasai now increasingly enroll their children in school which means that they have less time with parents compared to the situation in the past (Kiringe 2005). In addition, school teachers often come from outside the Maasai community and local traditions are not high on the teaching agendas. As a result, the transfer of medicinal plants knowledge from parents to children is diminished. In addition, as the elders die, traditional plant wisdom including general ecological knowledge is in danger of being lost if it is not recorded and passed on.

Local knowledge has been used in biodiversity conservation and sustainable management of natural resources and is an irreplaceable resource that should be cultivated (Berkes and Davidson-Hunt 2006). The disappearance of medicinal plant resources and the knowledge related to them would have devastating effects on the Maasai community. People's preferences of use of medicinal plants are influenced by factors such as availability (Lucena et al. 2007, 2012) and efficacy (Khafagi and Dewedar 2000). The ecological apparency hypothesis states that the easiest found plants are the most commonly collected and used by people (Feeny 1976). The "apparent" plants will be better known to people and will have high use values (Phillips and Gentry 1993a, b). Plants with high use values are likely to experience high collection pressure. The few ethnobotanical studies conducted in the Loita area (Maundu et al. 2001; Ongugo et al. 2011) did not distinguish medicinal plants with high use values, and they did not point to local protection mechanisms. Therefore, there is an urgent need to identify and document the most commonly used medicinal plants for sustainable utilization and to facilitate conservation planning (Maroyi 2011). In their conclusion, Maundu et al. (2001) recommended that: (1) conservation measures should be put in place to remove threats to the local flora, (2) systems to monitor the local natural resources should be developed, and (3) traditional institutions should be involved in natural resource management. Two decades later, these recommendations have not been followed up on, not least because the needed basic information has not been available.

In order to come up with sustainable natural resource conservation measures, it is important to understand the management strategies of the local communities who are the custodians of these resources. Studies to investigate the local management strategies to protect medicinal plants have not been carried out in Loita.

Therefore, our research was designed to add new knowledge on commonly used traditional medicinal plants, their uses, and the local conservation strategies developed to protect them. Apart from providing new knowledge, such information can serve to develop sound and adaptive management programs for prioritized medicinal plant species that ensure both human and ecosystem health. In this context, the specific objectives of our study were to; (1) identify and document the medicinal plants most commonly used by the Loita Maasai, (2) record the uses of medicinal plants identified, (3) highlight the parts of the plant used, methods of preparation, and their application, and (4) explore the traditional conservation strategies that protect medicinal plants in the study area.

2 Methods

2.1 Study site and population

The study site was the Loita area that borders the Nkurumani-Magadi escarpment to the east, Tanzania to the south, and the Maasai Mara National Game Reserve in Kenya to the west (Fig. 1). The Loita area has savanna lowlands, evergreen bushland, and upland dry forest. Its annual rainfall ranges from 600 to 1270 mm, with the wettest season in April and May and the driest season in September and October. The temperatures varies from 20 to 30 °C in the rangelands and 17–20 °C in the forest, although temperatures in the forest sometimes go as low as 10 °C in mid-June to July (Saitabau 2011).

The most important forest in the Loita area is *Naimina Enkiyio* which covers 330 km^2 at 1700–1900 m above sea level and is the main water catchment area for the community. The forest is the only remaining closed canopy, truly natural forest in Kenya

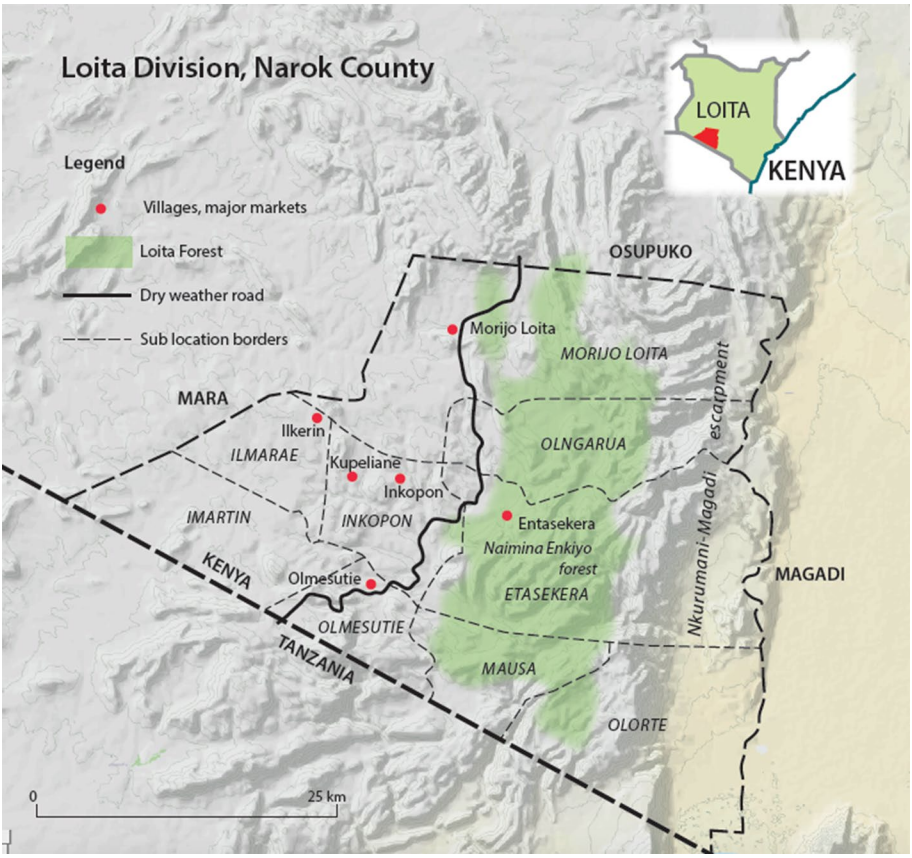

Fig. 1 Map of Loita area where we studied the use of medicinal plants among the Loita Maasai

(Ongugo et al. 2011). *Naimina Enkiyio* (meaning "forest of the lost child") is owned and managed by the Loita Maasai, and it is an important source of medicinal plants, firewood, and edible fruits. The forest has a cultural significance to the community, and it is where various traditional ceremonies are performed. Loita is home to a population of estimated 24,000 people, with an average population density of 10 people/km^2, most of whom live on the open western edge of the *Naimina Enkiyio* forest (Maundu et al. 2001). The surrounding vegetation includes six vegetation types: grassland, wooded grassland, thickets, montane, sub-montane, and bushland. The area has few social facilities such as churches, modern health clinics, and primary and secondary schools.

We conducted our fieldwork in three villages: Ilkerin, Inkopon, and Entasekera (Fig. 1). Ecosystem services provided by the forest are shared by all community members who, in turn, are responsible for using the natural resources sustainably. The *Council of Elders,* which is appointed by the local community, is tasked with managing and making decisions about the use of the natural resources in the area. As a result of their geographical isolation, Maasai of Loita have less interaction with other tribes, and this has helped conserve their traditions more than most other Maasai groups have (Maundu et al. 2001).

2.2 Permits

The investigation was approved by the Institutional Review Board (IRB), Number IRB2013-149, issued for Clemson University, where this study was carried out as a M.Sc. thesis project. Additionally, informed oral consent was obtained before each interview. Ethical research procedures involving confidentiality, anonymity, and the rights of withdrawal were followed.

2.3 Fieldwork and interviews

Fieldwork was conducted between the months of June and August 2013. A total of 31 informants (13 women, 18 men) all above 18 years of age were interviewed about medicinal plants in three Loita villages: Ilkerin, Inkopon, and Entasekera (Fig. 1). The precise age of the informants could not be determined because 90% did not know their age. The informants were identified through purposive and snowball sampling, a qualitative technique used to select new informants based on recommendations from the ones already interviewed (Babbie 2010). Purposive sampling was initiated by identifying the *Oloiboni*, the Maasai leader and medicinal plant expert in the Loita community, and the three villages included in the study. His recommendations included one elder from each village, and using the snowball sampling technique, each individual interviewed was asked to recommend the next informant until no new names were suggested. The interviews were conducted in Maa language, and answers were recorded by the first author who is a native Maa speaker. In addition, the interviews were documented using a recording device for verification of handwritten information. The interviews began with free-listing of known traditional medicinal plants (Quinlan 2005). The informants were given as much time as needed to compile their lists orally. Plant species were recorded in the order they were given. Subsequently, we asked questions in all interviews about: (1) the listed medicinal plant uses, (2) location, (3) perception of availability, and (4) the traditional conservation strategies, if any, put in place by the community members. In November 2018, we revisited the study area to check on the accuracy of some of the original data, particularly concerning the plant parts used and preparation methods.

2.4 Data analysis

Analyses were conducted using the ANTHROPAC 4.983 software, which reads free-list datasets (Borgatti 1996). We determined the number of times each plant was listed (i.e., frequency), the percentage of informants who mentioned each medicinal plant, the ranking of each plant on each free-list, as well as the average rank on all lists together (i.e, the average ranking). The frequency and average rank were used to produce the Smith's salience score, which is used to measure knowledge that is shared by informants (Table 1). To identify the most commonly used traditional medicinal plants, we used both frequency and Smith's salience (Smith 1993). For qualitative data, we used an inductive approach to generate codes (Galman 2007) and themes. This approach was suitable because the process is data driven (Braun and Clarke 2006) and the themes developed are strongly linked to the data themselves (Patton 1999).

Table 1 Sixty-two free-listed traditional medicinal plants mentioned by 31 informants (13 women and 18 men) in three Loita Maasai villages (lkerin, Inkopon, and Entasekera) in southern Kenya

Species (herbarium voucher number and family)	Maasai name	Uses	Plant part used	Preparation methods	Use category	Frequency of citations	Smith's S
Rhamnus prinoides L'Hér.; Rhamnaceae (001)	Orkonyil	To treat sexually transmitted disease (gonorrhea), backaches	B, F, MP	D, M	P, I	27	0.554
Toddalia asiatica (L.) Lam.; Rutaceae (002)	Oleparmunyo	Used to treat malaria	B, MP, R	D, M	I	25	0.476
Vachellia gerrardii (Benth.) P. J. H. Hurter; Leguminosae (003)	Olng'ong'uenyi	Used during delivery to expel the placenta and to clean the placenta after birth	B, BR, MP, R, S	D	P/B	24	0.396
Searsia natalensis (Bernh. ex C. Krauss) F. A. Barkley; Anacardiaceae (004) (004)	Olmisigiyioi	Given to children to treat upset stomach and diarrhea; used for teeth cleaning	B, MP, R, S	D, M	D, M	24	0.354
Carissa spinarum L.; Apocynaceae (005)	Olamuriaki	Used to treat diarrhea, pelvic pains and backache	B, F, MP, R, S	D, E	P, D	22	0.408
Vachellia nilotica (L.) P. J. H. Hurter and Mabb.; Leguminosae (006)	Olkiloriti	Used for digestion disorders and also used to treat upper respiratory diseases	B, MP, R, S	D, M	D, R	21	0.454
Olea europaea L.; Oleaceae (007)	Oloirien	Treatment of upset stomach and intestinal worms	B, L, MP, S	D, M	D	17	0.296
Warburgia salutaris (G. Bertol.) Chiov.; Canellaceae (008)	Osokonoi	Cleansing of the uterus, common cold, aiding in healing after delivery, stomach pains	B, BR, F, L, MP, R, S,	D, M	P/B, I, P	16	0.295
Olinia rochetiana A. Juss.; Penaeaceae (009)	Olkirenyi	Used for cough, pneumonia treatment	B, L,	D, M, E	R	16	0.190

Table 1 (continued)

Species (herbarium voucher number and family)	Maasai name	Uses	Plant part used	Preparation methods	Use category	Frequency of citations	Smith's S
Combretum molle R.Br. ex G. Don; Combretaceae (010)	Olmaroroi	Used to treat backache and sexually transmitted diseases	B, BR, F, MP	D, M	P, I	14	0.213
Osyris lanceolata Hochst. and Steud.; Santalaceae (011)	Olosesiai	Used to promote good health and boost body ability to fight diseases	B, BR, MP, R, S	D, E	IM	14	0.210
Albizia amara (Roxb.) B. Boivin; Leguminosae (012)	Olperrelengo	Muscle and bodybuilding for the Moran (warriors), indigestion, smooth baby skin and softens baby feces	B, BR, F, R, S	D	D, S	14	0.323
Myrsine africana L.; Primulaceae (013)	Oseketeki	Used for deworming, headache, malaria and stomach problems	F, MP, R	D, E, P/C	P, I, D	14	0.252
Ximenia americana L.; Olacaceae (014)	Olamai	Used for general body strength	B, F, MP, R, S	D, E	IM	13	0.222
(015)	Kilaki Orkerr	Soup—used to boost general health, bodybuilding and increase of blood in the body	BR, F, L, MP, R, S	D, E	IM, BS	12	0.226
Rhamnus staddo A. Rich.; Rhamnaceae (016)	Orkokola	Used to treat diarrhea	B, MP, R, S	D, DR, M	D	12	0.188
Zanthoxylum usambarense (Engl.) Kokwaro; Rutaceae (017)	Oloisuki	Used to treat malaria, backache and joint pains	B, L, MP, R, S	D	I, P	11	0.122
Trimeria grandifolia (Hochst.) Warb.; Salicaceae (018)	Oledat	Used for coughs and backache	B, BR, L, MP, R, S	D, S	P, R	11	0.205
Aloe kedongensis Reynolds; Xanthorrhoeaceae (019)	Osukuroi	Used for malaria, headache and to increase appetite	BR, L, MP, R, S	D, M, E P/C	I, P	11	0.174

Table 1 (continued)

Species (herbarium voucher number and family)	Maasai name	Uses	Plant part used	Preparation methods	Use category	Frequency of citations	Smith's S
Phragmanthera usuiensis (Oliv.) M. G. Gilbert; Loranthaceae (020)	Entaretoi	Used to clean umbilical cord wound	BR, L, MP, R, S	D, M	S	10	0.100
Turraea abyssinica Hochst.; Meliaceae (021)	Enchani–Nkashe	Used for general body strength	B, BR, R, S	D, M	IM	10	0.153
Vernonia abbotiana O. Hoffm.; Compositae (022)	Ologumati	Used to treat brucellosis and for inflammation of joints	BR, MP, R	D, M, E	BS, IN	10	0.144
Scutia myrtina (Burm.f.) Kurz; Rhamnaceae (023)	Osanankoruri	Used as an immunity booster	F, MP, R, S	D, E	IM	9	0.158
Faurea saligna Harv.; Proteaceae (024)	Olng'eriantus	Used to treat stomach problems/upsets/ulcers, urinary tract infections	MP, R	D	M, D, I	8	0.105
Pappea capensis Eckl. and Zeyh.; Sapindaceae (025)	Oltimigomi (Enkorrirri)	Only used by warriors to be brave and fierce and as a body/muscle builder. Used with Soup—(very poisonous tree). Used to treat tuberculosis	B, F, MP, R, S	D, M	I	8	0.167
Vachellia drepanolobium (Harms ex Sjostedt) P. J. H. Hurter; Leguminosae (026)	Oluai	Used to treat tuberculosis	B, F, MP, R	D, E	I	8	0.133
Acacia sieberiana DC.; Leguminosae (027)	Oltarara	Given to women after delivery to help in healing	B, BR, F, R, S	D	P/B	8	0.107
Vepris nobilis (Delile) Mziray; Rutaceae (028)	Olgelai	Used as toothbrush and roots are used to treat Brucellosis	L, MP, R, S	D	I, BS	6	0.078

Table 1 (continued)

Species (herbarium voucher number and family)	Maasai name	Uses	Plant part used	Preparation methods	Use category	Frequency of citations	Smith's S
Gymnosporia heterophylla (Eckl. and Zeyh.) Loes.; Celastraceae (029)	Olaimurunyai	Used to clean circumcision wounds in both girls and boys	B, BR, MP, R, S	D, M, S	S, IN	6	0.114
Sarcostemma stocksii Hook. f.; Apocynaceae (030)	Oloilei	Used to treat eye infections	R, S	D	I	5	0.094
Erythrina abyssinica DC.; Leguminosae (031)	Oloponi	Infertility and urinary tract infections	B, R, S	D, E, S	I, IN	5	0.071
Rotheca myricoides (Hochst.) Steane and Mabb.; Lamiaceae (032)	Olmakutukut	Used as an antibiotic to treat malaria and venereal disease	R	D	I	4	0.061
Solanum incanum L.; Solanaceae (033)	Entulelei	Used to treat sore throat and mouth wounds	BR, MP, R, S	D, E	R, I	4	0.079
Cordia monoica Roxb.; Boraginaceae (034)	Oseki	Backaches	F, MP, R, S	D, E	P	4	0.069
Dovyalis abyssinica (A. Rich.) Warb.; Salicaceae (035)	Emorogi	Used to stop diarrhea	B, BR, F, MP, R	D, E	I, M	4	0.077
Strychnos henningsii Gilg; Loganiaceae (036)	Oltipilikua	Used to treat malaria	B, MP, R	D, M, E	I	4	0.081
Afrocarpus falcatus (Thunb.) C. N. Page; Podocarpaceae (037)	Olpiripiri	For general improvement of body health and recovery after illness	BR, MP, R, S	D	IM	3	0.067
Sansevieria suffruticosa N.E.Br.; Asparagaceae (038)	Oldupai	Used to treat gonorrhea	B, BR, MP, R, S	D	I	2	0.039
Euclea divinorum Hiern; Ebenaceae (039)	Olkinyei	Used to clean the stomach as a dewormer	B, L, MP, R, S	D, M	D	2	0.022

Table 1 (continued)

Species (herbarium voucher number and family)	Maasai name	Uses	Plant part used	Preparation methods	Use category	Frequency of citations	Smith's S
Vachellia seyal (Delile) P. J. H. Hurter; Leguminosae (040)	Olerai	Used to stop diarrhea	B, L, R, S	D, M	D	2	0.039
Senna didymobotrya (Fresen.) H. S. Irwin and Barneby; Leguminosae (041)	Osenetoi	Used to treat malaria	B, L, MP, R, S	D, DR, E	I	2	0.053
(042)	Enchani-Entile	Green leaves crashed and sniffed. Used to cure headaches and colds	BR, L, R, S	D, E	P, R	2	0.039
Ficus cordata Thunb.; Moraceae (043)	Osukunua	Used with soup to boost immunity and improve general health	B, MP, R, S	D	I	2	0.046
(044)	Oladardar	Used with soup—to cure pneumonia, stomach upsets and malaria	BR, R, S	D, M	I, D, R	2	0.020
Grewia damine Gaertn.; Malvaceae (045)	Ositeti	Chest pains, snake bites and cold	B, BR, F, MP, R, S	D, M	P, PO, R R	1	0.015
Sphaeranthus confertifolius Robyns; Compositae (046)	Oleturot	Used to wash newborn for smooth skin and also used by adults with skin condition	F, L, MP, R, S	D, M, E	S	1	0.002
Cassine aethiopica Thunb.; Celastraceae (047)	Olodong'anayioi	Used to treat pneumonia	B, F, MP, R	D, E	R	1	0.025
Albizia anthelmintica Brongn.; Leguminosae (048)	Emukutan	Stomach worms	BR, L, MP, R, S	D, M, E	M	3	0.004

Table 1 (continued)

Species (herbarium voucher number and family)	Maasai name	Uses	Plant part used	Preparation methods	Use category	Frequency of citations	Smith's S
Asparagus africanus Lam.; Asparagaceae (049)	Empere-E-Papa	Used as an antibacterial to clean circumcision wounds for boys.	L, R	D	S, IN	1	0.002
Cadaba farinosa Forssk.; Capparaceae (050)	Enchani Pus	Used to induce vomiting and reduce anemia in pregnant mothers	F, MP, R, S	D	N, P/B	1	0.008
Ficus sycomorus L.; Moraceae (051)	Orng'aboli	Cleans uterus after birth and helps in stopping bleeding after birth	BR, F, MP, R, S	D, E	P/B	1	0.010
Prunus africana (Hook.f.) Kalkman; Rosaceae (052)	Orkujuk	Used to wash newborn babies to shed off dead skin, to increase appetite, reduce fever, stomachache and cure malaria	MP, R, S	D	I, S, P	1	0.025
Pennisetum hohenackeri Hochst. ex Steud.; Poaceae (053)	Olmakutian	Malaria	B, BR, R	D	I	1	0.013
Euphorbia candelabrum Trémaux ex Kotschy; Euphorbiaceae (054)	Olpopongi	Used to treat gonorrhea, flu and joint pains	B, BR, R, S	D	P, I	1	0.030
Allophylus sp.(055)	Enchani-E-Mbae	Used to stop diarrhea	R	D	D	1	0.005
(056)	Enchani-Enkerr	Use to cure gonorrhea	R, S	D	I	1	0.003
Solanecio angulatus (Vahl) C. Jeffrey; Compositae (057)	Olairamirami Pus	Used as mouth wash and tooth cleaning	R, S	D S	D	1	0.011
Turraea mombassana C. DC; Meliaceae (058)	Onchani Orok	Malaria	F, MP, R, S	D, M, E	I	1	0.006

Table 1 (continued)

Species (herbarium voucher number and family)	Maasai name	Uses	Plant part used	Preparation methods	Use category	Frequency of citations	Smith's S
Euphorbia uhligiana Pax; Euphorbiaceae (059)	Enkushuri	Used to cure wounds by applying the sap. Treatment of colds.	BR, F, MP, R	D, M, E	S, I	1	0.004
Balanites glabra Mildbr. and Schltr.; Zygophyllaceae (060)	Olng'osua	Pneumonia, aids in vomiting to clean the stomach	BR, F, MP, R	D, DR, E	R, D	1	0.031
(061)	Olemedung'i	Joint pains, keeps body warm	MP, R, S	D	P, C	1	0.014
Acacia robusta Burch.; Leguminosae (062)	Ormumunyi	Facilitates placenta expulsion	MP, R	D, M	P/B	1	0.032

Use categories follow Cook (1995): *I* infections; *P* pain; *R* respiratory conditions; *D* digestive problems; *S* skin conditions; *IM* immune system disorders; *P/B* pregnancy and birth-related conditions; *BS* blood system disorders; *M* metabolic system disorders; *IN* inflammations; *N* nutritional-related conditions; *B* circulatory system disorders; *PO* poisoning. Plant parts used; *B* bark; *F* fruits; *MP* multiple parts; *BR* branches; *S* stem; *L* leaves; *R* roots. Preparation methods: *D* decoction; *DR* dried; *M* maceration; *S* squeezed; *E* eaten; and *P/C* pounded/crushed

3 Results

3.1 Commonly used medicinal plants

Our informants mentioned 62 different traditional medicinal plants species in the free-listing (Table 1). The nine most frequently used species (Table 2) were *Rhamnus prinoides* L'Hér., *Toddalia asiatica* (L.) Lam., *Vachellia nilotica* (L.) P. J. H. Hurter and Mabb., *Carissa spinarum* L, *Acacia gerrardii* Benth., *Searsia natalensis* (Bernh. ex C. Krauss) F. A. Barkley, *Albizia amara* (Roxb.) B. Boivin, *Olea europaea* L., and *Warburgia salutaris* (G. Bertol.) Chiov. Three species that were top ranked on Smiths' S list (*O. europaea W. salutaris,* and *A. amara*) had low frequencies but high ranking, resulting in a high Smith's S score (Smith 1993). Three of the nine commonly known medicinal plants belong to the family Leguminosae, while the six remaining species belong to Rhamnaceae, Rutaceae, Apocynaceae, Anacardiaceae, Oleaceae, and Canellaceae, respectively.

Men listed an average of 16 medicinal plants while women listed an average of 15 medicinal plants. In the list of the most commonly used medicinal plants (Table 2), the frequency of mention was higher for men than women.

Out of the 62 free-listed medicinal plants, four (*Kilaki Orkerr, Enchani-Entile, Oladardar,* and *Olemedung'i*) could not be identified by their scientific names. This list of the Loita Maasai's medicinal plants shows that they still use traditional medicine and the knowledge is broadly represented among community members.

3.2 Parts of the plant used, methods of preparation, and application

The most frequently used plant parts were roots, stem, and bark (Fig. 2). However, the use of multiple parts was also quite common and accounted for 17% of the total uses reported. The roots were the plant part with the highest number of uses reported, meaning that roots are the preferred part of the plant for medication. The leaves and branches had the lowest number of uses reported. Preparations included decoctions, maceration, and eaten raw (Fig. 3). Decoctions were prepared and ingested, while some medicinal plant were applied to the body's affected areas.

3.3 Use categories of medicinal plants

The uses of medicinal plants by the Loita Maasai represented most of the categories listed in the *Economic Botany Data Collection Standard* (Cook 1995). The Loita Maasai often use more than one plant species to treat the same health condition; only 37% of the free-listed plants had a single use, while the remaining 63% had more than one usage. For example, *Toddalia asiatica* (L.) Lam. was only used to treat malaria, whereas *Carissa spinarum* L. was used to treat diarrhea, pelvic pains, and backache. The most common use category of health condition that was treated with medicinal plants was infections, which were treated with 27 different species. These were followed by pain, which was treated with 14 species, respiratory diseases treated with 13 different species and digestive problems treated with 12 species. Less than seven species were used for treating skin diseases, immune system disorders, pregnancy-/

Table 2 List of nine most commonly used medicinal plants by the Loita Maasai in Kenya

Scientific names	Frequency of mention by men	Frequency of women by women	Use category	Family
Rhamnus prinoides L'Hér.	18	8	P, I	Rhamnaceae
Toddalia asiatica (L.) Lam.	17	9	I	Rutaceae
Vachellia nilotica (L.) P. J. H. Hurter and Mabb. (L.)	16	5	D, R	Leguminosae
Carissa spinarum L.	17	5	D, R	Apocynaceae
Acacia gerrardii Benth.	17	7	P/B	Leguminosae
Searsia natalensis (Bernh. ex C. Krauss) F. A. Barkley	16	8	D, M	Anacardiaceae
Albizia amara (Roxb.) B. Boivin	12	2	D, S	Leguminosae
Olea europaea L.	10	7	D	Oleaceae
Warburgia salutaris (G. Bertol.) Chiov.	10	6	P/B,	Canellaceae

I infections; *P* pain; *R* respiratory conditions; *D* digestive problems; *S* skin conditions; *P/B* pregnancy and birth-related conditions; *M* metabolic system disorders; and *B* circulatory system disorders

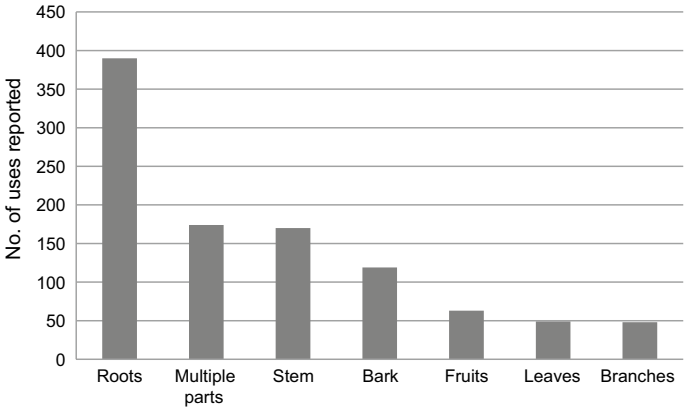

Fig. 2 Parts used of 62 medicinal plant species by the Loita Maasai of Kenya, indicating number of uses reported

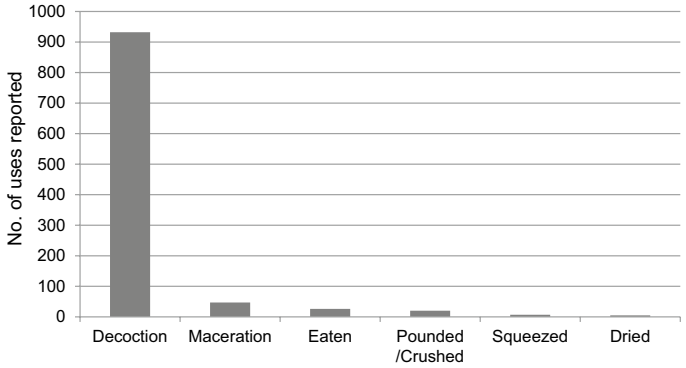

Fig. 3 Number of uses reported for each method of preparation for the 62 plants used as medicine by the Loita Maasai of Kenya

birth-related conditions, blood system disorders, metabolic system disorders, inflammation, nutritional problems, circulatory conditions, and poisoning.

3.4 Perceived availability of medicinal plants

Two-thirds of the informants (68%) believed that there had been a change in the availability of plants compared to the past, while 23% believed that the availability of medicinal plants was the same as in the past. The informants, who said that it was easier to find medicinal plants in the past than now ($N = 21$), believed that the change in availability was due to deforestation, population increase, and drought.

3.5 Local conservation strategies for medicinal plants

The Loita Maasai had their own strategies to protect medicinal plants which included a local harvesting strategy that ensured that plants were not damaged and that the community would be able to harvest from them in the future. For example, participants reported that when collecting roots of trees and shrubs, they cut only a few and main roots should not be cut or dug up. The small roots or offshoots of the main roots are the ones harvested to minimise the effect on tree's growth and future. Also, it was reported that collection of bark and branches from a plant species that showed signs of previous collection from the same individual may have a negative impact on the tree's survival. In that case, a plant should be left to enable its recovery from the effects of the past collection. However, they did not have clear and precise mechanisms for conserving tree species whose leaves and fruits are the main parts used. They believed the leaves and fruits are always available in abundance, and hence, there was no need for conservation measures.

They ensured sustainable use of their shared resources by monitoring the resources regularly, which was a collective conservation strategy, and a responsibility of the community which involved looking out for any possible threats such as overexploitation of medicinal plants in the forest. When overexploitation was noted, they would move the collecting activity to other areas to allow for regrowth of the over-used plant population. The Loita Maasai claimed that they practiced sustainable harvesting without damaging the plants, thus ensuring their future availability. To ensure that the community's natural resources are not depleted, they had a well-established community structure known as the *Council of Elders,* appointed by the community and charged with overseeing the management of natural resources in the study area.

4 Discussion

Among indigenous tribes such as the Maasai, traditional medicinal plants are believed to be safe, and not only desirable but also efficient in the treatment of several human health problems (Maundu et al. 2001). Men listed an average of 16 plants while women listed an average of 15 plants. This shows that men and women have almost equal knowledge of medicinal plants, but there was variation in the knowledge of specific medicinal plants. Men knew more plants that are commonly used than the women did (Table 2). For example, *Rhamnus prinoides* which was used to treat venereal diseases and back pain had a higher frequency of mention by men (58%) than by the women (26%).

The common diseases treated by use of medicinal plants were infection, pain, respiratory disease, and digestive problems. A previous study reported that malaria, fever, brucellosis, gastrointestinal problems, and infections of the urinary track were the most common diseases in the study area (Maundu et al. 2001), which agrees with our finding that infections are the most common use category for medicinal plants. These results also agree with those obtained in Thailand (Phumthum et al. 2018), where they recorded over 2000 use reports for infections.

The most commonly used parts of the plant were roots, stems, and the bark. Similar findings have been reported elsewhere in Kenya, where roots and stems were the preferred parts used (Kimondo et al. 2015; Kokwaro 2009). In contrast, other studies have cited leaves as the most commonly used plant part (Fortini et al. 2016; Mukungu et al. 2016;

Yemele et al. 2015). Harvesting of leaves is argued to be sustainable in the long term since they are available in abundance and easily regrow (Mukungu et al. 2016) as compared to roots and stems (Junsongduang et al. 2014; Srithi et al. 2009). Therefore, the reliance on roots, stems, and bark for medication in our study area may pose threats in the near future to the existing medicinal plants, especially those highlighted as commonly used.

The Loita Maasai collected their medicinal plants around their villages and from *Naimina Enkiyio* forest. From our observations during fieldwork, none of the medicinal plants were cultivated. Informants reported that collection was done by an individual (45%) if they were not very sick; when they felt very sick, they would send relatives or friends (55%) to collect the needed medicinal plants. However, in cases where the health problem became complicated or did not improve after treatment, a specialist would be consulted, most commonly the *Oloiboni,* who was the overall expert herbalist in the community while others would go to health clinics for further treatment.

Two-thirds of our informants believed that the medicinal plant species were becoming rare and more difficult to find nowadays, compared to the past due to deforestation, changes in lifestyle, population increase, and drought. The Maasai have started to adopt a sedentary lifestyle in contrast to their original nomadic lifestyle. This change in lifestyle has had negative impact on both the environment and the medicinal plants (Okello and Kiringe 2004; Kiringe 2005). In addition, increase in the human population and prolonged droughts may also have contributed to changes in the availability of medicinal plants. Moreover, the perceived changes in medicinal plants availability may be due to the fact that most species used in the study area are trees which take a long time to grow; hence, the use of roots and bark may not be sustainable for future generations.

The Maasai traditional medicinal plant expertise is a result of their way of life, which is interwoven with their environment. Through their experience and observations, the Maasai became eco-literate, meaning they were able to identify local plants and use their ecological knowledge in their conservation. The Loita Maasai did not plant or cultivate medicinal plants on their farms, those found there occurred spontaneously. Interestingly, none of our informants reported buying the plants in the market, indicating that medicinal plants were not commercial items bought and sold in the study area. The possible reason for this could be the close proximity of the people to the forest, to which the community members have free access.

To ensure that the medicinal plants were not depleted, the Loita Maasai had traditional strategies to ensure sustainability. For example, they practiced selective harvesting. Among the Loita Maasai, it was unacceptable to harvest from an already harvested plant. One had to look for the same species elsewhere in the forest to do additional harvesting. In addition, community members were required to harvest from mature plants in cases where entire plant or their roots were needed for use. Selective harvesting has been used by many indigenous communities for both plants and animals (Colding and Folkes 2001). For example, to ensure sustainable use, the Sami people in northern Finland harvested under the best possible conditions during appropriate temperatures and seasons, and before harvesting, the abundance and distribution of species were taken into consideration (Bjørklund 1990; Ingold and Kurttila 2000). Monitoring was also a common strategy among the Loita Maasai, one that was well known and deeply rooted in the culture (Okello and Kiringe 2004). Resource monitoring is commonly done by indigenous people to protect their environment, using skills acquired through many years of living and interacting with their environment (Berkes and Davidson-Hunt 2006). For example, the decision of Sahel herders to move to a new grazing area was guided by their daily observations of the pastures (Niamir-Fuller 1998).

To secure effective use of natural resources, the Loita Maasai had a community structure in place for resource management; the *Council of Elders*, composed of members elected by the community, were tasked with overseeing the management of natural resources in the area.

The *Council of Elders* had the authority to restrict harvesting of a species to certain times of the year depending on collection pressure. A temporary restriction in the harvesting of natural resources has been a common practice elsewhere, not only used to protect medicinal plants but also to control harvesting of fish and wildlife. In North America, hunting, fishing, and trapping areas were periodically restricted for a certain period of time to allow "resting" time for regeneration (Berkes 1999).

The natural resources protection strategies encountered among the Loita Maasai are similar to others described in the literature (Olmsted and Alvarez-Buylla 1995; Turner et al. 2000). Parts of the plants harvested determine the sustainability of species, and harvesting a high percentage of bulbs could result in the decline of certain species (Nault and Gagnon 1993), leading either to extinction with limited capacity to recover or requiring many years to recover due to environmental conditions and other factors (Rock et al. 2004; Ticktin and Nantel 2004).

In Shey Phoksundo National Park, medicinal plants were harvested only for local use, and the Amachi people living there had an approach that ensured that plants harvested would regenerate. Their harvesting strategies were based on their ethnoecological knowledge. In addition, selective harvesting strategies were used to protect the plants, including the harvesting of mature plants only, harvesting during specific seasons and observing signs of overgrazing, and overharvesting (Hamilton and Radford 2007). These strategies are similar to those used by the Loita Maasai to protect their medicinal plants.

5 Conclusions and recommendations

Despite the introduction of formal schooling and modern health clinics, the Loita Maasai have kept their traditional medicinal knowledge intact. Because the Loita Maasai collected their medicinal plants from the *Naimina Enkiyio* forest, and because medicinal plants were not cultivated, the most commonly used species could potentially be subject to a higher collection pressure compared to other free-listed species. In addition, the preference to use roots and bark for medication compared to other parts of the plant may pose sustainability challenges in the study area where medicinal species are mainly trees. These may explain the perceived changes in availability as reported by participants because the species require a long time to grow, hence becoming hard to find within the vicinity from most homes in the study area. Therefore, future research should be directed toward creating the basis for developing sustainability measures with information about the parts commonly used in mind. In addition, the use of leaves and fruits should be encouraged as it may not pose a threat to the tree species concerned compared to the use of roots.

For long-term sustainability, taking into account the ongoing cultural change from nomadic pastoralism to sedentary communities, studies should investigate the possibility of cultivating these salient medicinal species either on farms or in the villages. These will increase availability of medicinal plants in the future. Studies should also be conducted to determine their abundance and harvesting patterns with the aim of establishing an available stock of these species and to investigate whether the current harvesting strategies will remain sustainable.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethics approval This study obtained Institutional Review Board (IRB) approval, Number IRB2013-149 from Clemson University, USA, where it formed part of the first author's M.Sc. study.

Informed consent The data collection was done with prior permission, and informed consent was obtained verbally from all participants. Ethical research procedures involving confidentiality, anonymity, and the rights of withdrawal were followed.

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