RESEARCH ARTICLE

UPDATED Local indigenous knowledge about some medicinal plants in and around Kakamega forest in western Kenya [v2; ref status: indexed, http://f1000r.es/UDNyBK]

Nickson Erick Otieno[1], Caleb Analo[2]

[1]National Museums of Kenya, Nairobi, Kenya
[2]Kakamega Environmental Education Project, Shinyalu, Kenya

v2 **First published:** 31 Oct 2012, **1**:40 (doi: 10.12688/f1000research.1-40.v1)
Latest published: 13 Dec 2012, **1**:40 (doi: 10.12688/f1000research.1-40.v2)

Abstract

Kakamega forest is Kenya's only rainforest and is distinguishably rich in biodiversity but threatened by agricultural encroachment and other forms of human activity. It is also one of Kenya's Important Bird Areas and a significant source of natural products to neighboring rural communities, such as medicinal plants, food, wood and other fibers. By using structured questionnaires for direct interviews, local indigenous knowledge was tapped through involvement of a focal group of elderly key informants in three blocks of the forest. Forty key species of medicinal plants used by local people were identified and recorded. Fifty-five percent of these were shrubs, thirty-two percent trees, seven-and-a-half percent lower plants such as herbs or forbs while five percent were climbers. About seventy percent of the medicinal plants occurred inside the forest itself and thirty percent around the edge and the immediate surroundings outside the forest. Thirty-eight (95%) of the plants were indigenous to Kenya and two (5%) exotic. Such extensive indigenous knowledge of the medicinal uses of the plants, including their distribution trends in the forest, may be tapped for decision support in rural health service planning, policy formulation for conserving the forest, tracking and mitigation of climate change impacts.

Article Status Summary

Referee Responses

Referees	1	2
v1 published 31 Oct 2012	report 1	report 1
v2 published 13 Dec 2012 UPDATED	report	report

1 **Martin Potgieter**, University of Limpopo South Africa

2 **Hugo Asselin**, Université du Québec en Abitibi-Témiscamingue Canada

Latest Comments

No Comments Yet

Corresponding author: Nickson Erick Otieno (neotieno@yahoo.com)

How to cite this article: Otieno NE and Analo C (2012) **Local indigenous knowledge about some medicinal plants in and around Kakamega forest in western Kenya [v2; ref status: indexed, http://f1000r.es/UDNyBK]** *F1000Research* 2012, **1**:40 (doi: 10.12688/f1000research.1-40.v2)

Grant information: Funds for the project were kindly provided by The Conservation Foundation in UK under its Young Scientist for Rainforests award scheme. The grant was awarded to Nickson Otieno. The grant had no grant number.
The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Competing interests: No competing interests were disclosed.

First published: 31 Oct 2012, **1**:40 (doi: 10.12688/f1000research.1-40.v1)
First indexed: 09 Jan 2013, **1**:40 (doi: 10.12688/f1000research.1-40.v2)

UPDATED **Changes from Version 1**

We have attempted to address and incorporate most of the concerns that were raised by the reviewers about the previous version of our manuscript. The reviewers generally felt that the method of selecting the respondents for the ethno-botanical survey was not clearly explained and might be construed to be biased. In our update we explain that we interviewed a total of 9 respondents with 3 focal/key ones with whom we went out on field excursions to identify and collect medicinal plant specimens, and another 6 (2 from each forest block, chosen randomly and did not join the excursions). Two of the respondents were female but all were elderly, chosen with advice and guidance from local leaders and field assistance. We also clarify that we mainly collected information about indigenous medicinal plants rather than comparing or analyzing local opinion about these plants. We also provided more background information and citations regarding medicinal plant research in Kenya and East Africa, which was scanty in the previous version, and put our own results into the perspective of these studies. We elaborated on our choice of classification criterion for diseases treated by the medicinal plants, including justification for the group "vector-borne" for the purpose of highlighting the very common diseases in east Africa such as malaria. We provided further postulations, based on other studies and background information, on why digestive-related diseases appeared predominant in local treatments using medicinal plants. Further, we incorporated the various changes and other comments suggested by the reviewers, including removing some repeated illustrations; writing the conclusions and recommendations more substantively to tie closely with the results; declaring how ethical issues about intellectual property rights were addressed and revising some taxonomic information that we had earlier got wrong or was missing.

See referee reports

Introduction

Although community development goals are not always consistent with biodiversity conservation objectives[1] there are often many opportunities for mitigating negative effects by tapping into local indigenous knowledge with reference to certain aspects of environmental use and conservation[2]. Indeed, application of knowledge and values of communities that are resident within or around key biodiversity areas has been gaining increasing global popularity as significant elements in enriching and improving strategies for conserving biodiversity[2]. This is because integration of such indigenous knowledge into conservation programs facilitates cross-borrowing of ideas, promotes constructive engagement, and instills a sense of common ownership and responsibility towards achievement of a synergy of goals[3]. This echoes the concept of social capital[3] that, apart from amassing local support and goodwill, adoption of local indigenous knowledge in conservation may also promote and provide sustainable insurance against conflicts of purposes. This results in increased chances of achieving the dual goal of biodiversity conservation stewardship as well as community development. For instance, studies have shown that rainforest ethno-botanical checklists prepared by communities living in or near them tend to be more exhaustive because they are based on practical day-to-day uses that are firmly ingrained in local cultural norms and values[3–5].

Like in many parts of the developing world, there is a growing upsurge in demand for herbal and other traditional remedies for various ailments among communities in Kenya. This is due either to the increasing cost of conventional modern medicine or, inadequacies in public health service delivery[6]. For a long time, the bulk of "technical" information on traditional plant uses in the treatment of disease has been disparate and privately held, with limited accessibility to the public or peer-review domain[7,8]. Fortunately, over the past five years there has been an upsurge in research and publication on indigenous knowledge and use of medicinal plants in Kenya. This includes research on medicinal plants of the Nandi forest[9], indigenous knowledge on medicinal plants of Mt. Elgon forest[10] and the uses of medicinal plants by the Ogiek people of the East Mau forest[11]. As a result, a firmer foundation is being laid gradually but steadily for further research into the effectiveness of these treatments and the various options for preparation and administration for managing diseases.

This study sought to set in motion a process for systematic documentation of plants of medicinal value in the Kakamega forest, with a view to consolidate indigenous knowledge about them and making this information available to the wider community. It is hoped that in the process of this, ecosystem and other socio-economic services offered by the Kakamega forest will be highlighted. The study also sought to highlight any plant species in the forest that may have medicinal value that are also of conservation concern, either as endangered or as invasive species.

Materials and methods

Study area: The Kakamega forest lies in western Kenya between 00°08′30.5″ – 00°23′12.5″ N and 34°18′ 08″ – 34°57′26.5″ E from 1520–1680 m above sea level[12–14] (Figure 1). The mean annual rainfall is 2000 mm, with long rains in April/May and short rains in September/October[12,13], while the mean annual temperature is 20°C. The forest covers 183 km^2 and 100 km^2 of this consists of closed canopy forest of which one-third, in the north, is gazetted as a national reserve under protection. The rest is comprised of grassy and bushed glades, tea, cultivation and plantations of softwoods and commercially valuable hardwoods[14,15].

The forest is Kenya's only true tropical rainforest[14] and constitutes one of Kenya's 61 Important Bird Areas (IBAs) due to the presence of about 350 bird species, many of which are range-restricted or endemic species reminiscent of the wider Guineo-Congolean forest system that extended from the eastern Democratic Republic of Congo, of which Kakamega is the easternmost outlying relict[15]. There are at least 380 plant species, though there is no significant endemism. As a result of massive exploitation through massive legal and illegal logging between the 1960s and 1990s, the forest flora is dominated by a mixture of large secondary-growth trees and hardly any primary-growth trees. Even for this secondary forest, much of the closed canopy and contiguity exists only in the northern part of the forest, consisting of the Buyangu blocks, which are now protected as a national wildlife reserve. The southern end, comprising of the Isecheno, Yala and Ikuywa as well as the detached units of

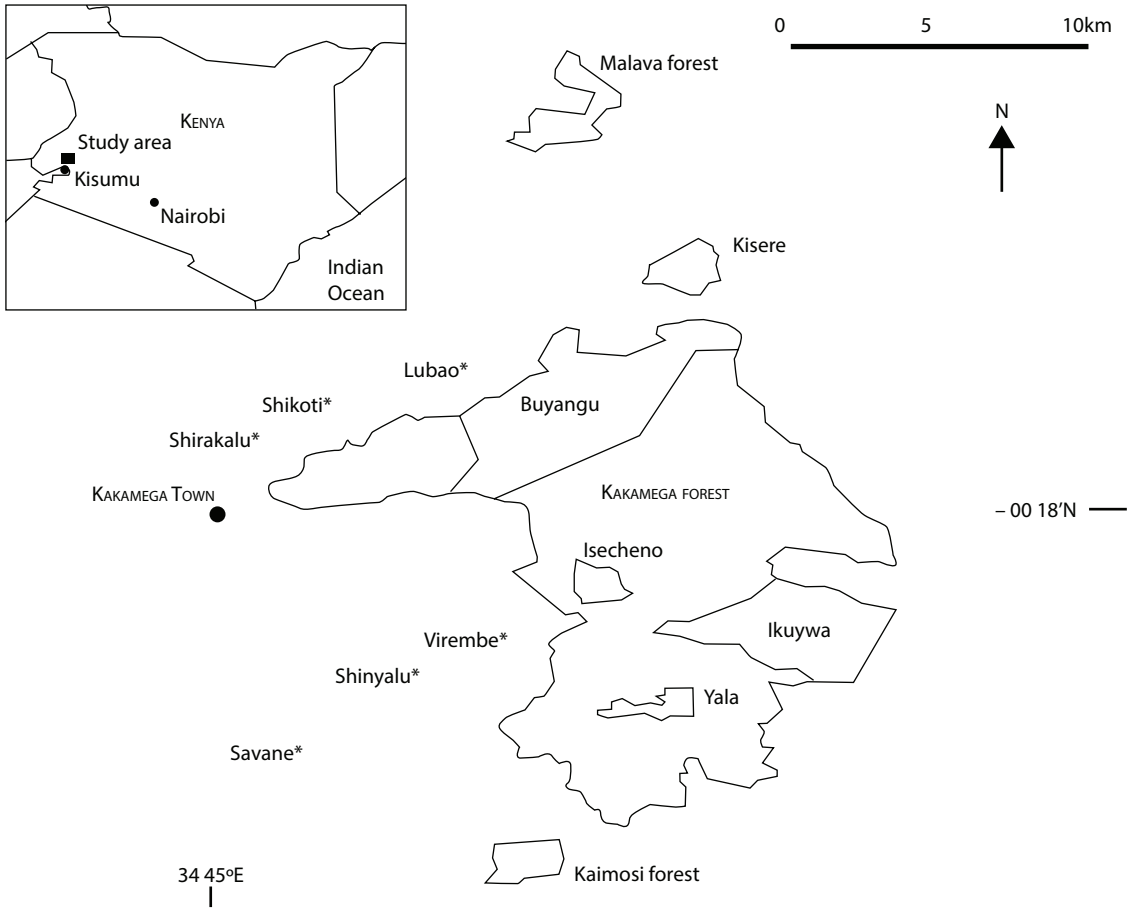

Figure 1. Map of Kakamega forest (this figure has been reproduced with kind permission from Otieno and co-authors[13]).

the Kisere, Kaimosi and Malava blocks (Figure 1), are managed as forest reserves but are still accessible to the local public community despite some level of official restriction.

Apart from birds and plants, the forest also has a remarkable richness in other biodiversity including several species of mammals, reptiles, amphibians and invertebrates[16].

The forest is under an increasing threat of loss to agriculture and settlement by the increasing local human population. The neighbourhood of the forest, where the western Kenya Bantu ethnic community called the Luhya reside, is densely populated with an average density of 433 persons per square kilometer[17,18].

The study was carried out within the three main blocks of the southern Isecheno-Yala-Ikuywa blocks, Buyangu, and the detached Kisere and Kaimosi blocks in the north (see Figure 1). The blocks were covered in two field seasons of 11 days each, the first between April and May 2009 while the effects of the wet season were still evident and many plants bore fruit and then in late July during the dry season when full fruiting is reduced and some leaves are shed off. This was to control for any rainy-season effects.

Sampling strategy: A key informant was identified from each study block during each sampling week, to be interviewed about the medicinal plants as outlined by Kothari[19]. The choice of blocks was primarily to achieve sampling with as much coverage of the forest as possible (including protected areas, reserves and detached fragments) though not necessarily to sample in every spatial part of the forest. Key informants were selected on the following criteria: (1) seniority of age in the community (not less that 50 years old); (2) local residency for a period of not less than 20 years; (3) knowledge of forest plants in the local dialect and well versed with their use(s). Current or previous experience as herbalist was preferable but not essential.

The selection was based on prior consultation with the local community leaders and additional guidance by field assistants according to Okello *et al.*[10] and prior consent was obtained before interviews. One of the key informants engaged in the interviews was a practicing traditional healer. Further information was obtained from random opportunistic interviews with 6 other non-core informants who were also at least 50 years old, 2 from each block. The choice of elderly informants was made on the basis that most indigenous knowledge about traditional medicine in developing countries tends to be possessed by elderly members of the society[20].

Data was collected from key informants through field excursions using direct personal interviews that employed the use of a structured questionnaire guided by a mix of closed and open-ended questions (see survey questionnaire). This was combined with free-style discussions and field excursions with the informants. For data consistency, the same informants were involved in each sampling season in each area. In addition, there was a final joint focused group discussion with all the key informants to synergize the information gathered. Information captured and recorded included:

1) Local name of plant in question; 2) Disease/condition treated by plant; 3) Plant part(s) used for the treatment; 4) Preparation method; 5) Indidgenous, common (English) and scientific name of the plants. These were determined by consulting illustrated standard botanical field guides[7].

Questionnaire provided to local informants to identify local medicinal plants

http://dx.doi.org/10.6084/m9.figshare.96908

Data analysis

A checklist of all recorded species of medicinal value was compiled, including their indigenous, common and scientific names, plant origination (i.e. indigenous or exotic), plant form (e.g. tree, shrub, herb etc.) and conditions treated (Table 1 and data set). Data was also presented in terms of the methods of preparation and administration to patients; as well as the age group and gender of target patients (data file below). All the lists generated by the different key informants were scrutinized and synchronized into a final list at the joint focused group discussion[20]. With help from the informants/respondents, each plant was observed in its natural habitat and a image taken using a digital camera, collected and pressed. For each medicinal plant, a small part (preferably one with flowers) was collected while fresh and digitally photographed for identification and pressed for herbarium. Species whose common (English) and scientific names were not immediately established in the field were taken for specialized identification at the EA Herbarium at the National Museums of Kenya in Nairobi.

Results and discussion

A total of 40 species of medicinal plants used by the people around the Kakamega forest were identified and recorded (Table 1 and data set). The species fall into 25 families (Table 2) and the list represents 11% of all plant species recorded in Kakamega forest[21]. It certainly not presumed here that the list of species from this study is a complete one for the Kakamega forest as, due to the constraints of time and resources, the study did not cover every part the forest. The most dominant families were Asteraceae, Fabaceae and Lamiaceae, each representing 10.3% of all species collected.

Medicinal plant species identified in and around Kakamega forest

1 Data File

http://dx.doi.org/10.6084/m9.figshare.96402

Of the 40 species, 22 were shrubs, 13 trees, 3 lower plants such as herbs or forbs, and 2 were climbers. This dominance of the shrubs also supports the prominence of the three families of Asteraceae, Fabaceae and Lamiaceae (Table 2). Twenty-six of the medicinal species occurred inside the forest itself and 14 occurred outside. One of the species *(Prunus africana)* is also listed in the IUCN Red List as vulnerable to extinction[22]. This species was encountered inside the forest while no other such threatened species was encountered outside the forest and this might underscore the forest reserve's role in aiding the conservation of medicinal species.

The majority of the species identified (95%) were indigenous and only 5% were exotic (Table 1) a fact that also reflects the localized nature of the indigenous knowledge about these medicinal plant species. For instances, despite the presence of *Eucalyptus sp* (family Myrtaceae) and *Grevillea sp* (family Proteaceae) in and around certain parts of the forest such as the Isecheno and Buyangu blocks, no informant mentioned any medicinal uses associated with them. Some *Eucalyptus* species are known to be used in treatment of certain bacterial or fungal infections in humans[23] while *Greville sp* is used in treatment of skin sores and as an antiseptic[24].

The total number of species recorded in this study compares closely to that recorded by Jeruto[9] in a study of medicinal plants used around the Nandi forest but is much smaller than the 107 species recorded in a study by Okello *et al.* for medicinal plants used by the Sabaot people around Mt. Elgon[10] and the 119 species recorded by Ndegwa of medicinal plants used by the Ogiek people in the East Mau forest[11].

The diseases reported to be treated using the plant species varied widely but were grouped into 14 categories including use in the treatment of a number of livestock diseases (Figure 2). Ninety percent of the diseases treated are those that affect humans and about ten percent for livestock diseases. Most of the human diseases treated using these species, fell into the categories of digestive or peptic; respiratory, vector-borne; and reproductive ailments (Figure 2). Furthermore, these treatments are applicable for both genders and almost all age groups except in 17% of the cases where the treatments are applicable to adults only and 7% of the cases where treatments were applicable for old people only. 37% of the species are used by the local people to treat more than one condition. One particular species *Azadirachta indica* (Table 1) is used by the local people to treat up to 6 different conditions, using all of its parts. This makes it the most valuable medicinal species even though it is of exotic origin[7]. In 17% of the species, more than one plant part is used in the treatment of various conditons, not necessarily in combination.

In preparing the treatments from the plants, the local people mainly use leaves, roots and barks, but in a few species, the treatment is derived from flowers, fruits and young shoots (Figure 3). Additionally, since many of the species are used in treating digestive or peptic, respiratory or vector-borne ailments, the majority of them are administered orally as an infusion, concoction, decoction or a lick of its powdered form[10]. The rest are applied either on the surface of the affected part of the body, through steam treatment, as fluid drops or through inhalation of either its fresh form or powder prepared from its crushed form.

Table 1. Checklist of the medicinal plants identified in and around Kakamega forest species accounts.

Scientific name	Local name	Common name	Family	Plant origin	Plant form	Diseases or conditions targeted
Albizia grandi bracteata	Mukhunzuli	Large-leaved Albizia	Fabaceae	Indigenous	Tree	Gonorrhea
Albizia gummifera	Musenzeli	Peacock flower	Fabaceae	Indigenous	Shrub	Sexually transmitted infections Stomach-ache
Azadirachta indica	*Muarubaini*	Neem tree	Meliaceae	Exotic	Tree	Fever, aches, pains Malaria attack Insect bites Pest control Skin infections
Aspilia pluriseta	Shralambila	Dwarf Aspilia	Asteraceae	Indigenous	Herb/ forbe	Stopping bleeding in wounds Drippy nose in poultry
Bequartiodendron oblanceolata	Musamia	Not established	Not established	Indigenous	Tree	Ulcers in digestive track Boils around belly
Chrysocephalum sp	Mwikalo	Yellow Buttons	Asteraceae	Indigenous	Shrub	Stomach problems related to STIs
Clematopsis scabiosifolia	Lunyili	Not established	Ranunculaceae	Indigenous	Climber	Stuffy nose and associated respiratory problems
Clerodendron pygmaeum	Luseshe	Cashmere Bouquet	Verbenaceae	Indigenous	Shrub	Common flu and associated
Coffea eugenioides	Itikwa	Mufindi coffee	Rubiaceae	Indigenous	Shrub	Eye problems in livestock
Conyza floribunda	Liposhe	Asthma weed	Asteraceae	Indigenous	Shrub	Tooth-ache
Desmodium adscendens	Matite	Not established	Fabaceae	Indigenous	Herb/ forbe	Stomach-ache
Desmodium repandum	Not established	Not established	Fabaceae	Indigenous	Shrub	Stomach upset
Diospyros abyssinica	Lusui	Giant Ebony	Ebenaceae	Indigenous	Tree	Recurrent nightmares Sores
Dissotis speciosa	Lunyili	Not established	Melastomataceae	Indigenous	Shrub	Diarrhea
Dovyalis macrocalyx	Shinavatevia	Shaggy-fruited dovyalis	Flacourtiaceae	Indigenous	Shrub	Constipation Peptic ulcers
Entada abyssinica	Shivayamboga	Abyssinia Entada	Leguminoceae	Indigenous	Tree	Stomach-ache

Scientific name	Local name	Common name	Family	Plant origin	Plant form	Diseases or conditions targeted
Erythrococca atrovirens	Shirietso	Not established	Euphorbiaceae	Indigenous	Shrub	Wounds, especially septic
Hibiscus sp	Lubulwa	Not established	Malvoideae	Indigenous	Shrub	Stomach-ache General fever
Justica flava	Lihululwa	Yellow Justicea	Acanthaceae	Indigenous	Herb/ forbe	Reducing post-natal pains
Lantana trifolia	Imbulimutacha	Three-leaf Shrub	Verbenaceae	Indigenous	Shrub	Malaria and general fever (humans) Diarrhea in livestock
Leucas calostachys	Lumetsani	Not established	Lamiaceae	Indigenous	Shrub	Severe diarrhea especially accompanied with blood
Leucas deflexa	Shitsunzune	Not established	Lamiaceae	Indigenous	Shrub	Eye infection/effects in livestock
Markhamia lutea	Lusiola	Nile Tulip tree	Bignoniaceae	Indigenous	Tree	Ear pain in humans Eye problems in cattle
Mondia whytei	Mukomer	White's ginger	Apocynaceae	Indigenous	Climber	Loss of appetite Low libido Fatigue Mineral deficiency
Ocimum kilimandscharicum	Not established	Kilimanjaro basil	Lamiaceae	Indigenous	Shrub	Nasal congestion, colds, flu, Insect bites General aches and pains
Olea capensis	Mutukhuyu	Elgon Olive	Oleaceae	Indigenous	Tree	Stomach-ache Peptic ulcers
Paullinia pinnata	Not established	Bread and cheese plant	Sapindaceae	Indigenous	Shrub	Hiccup
Paulownia tomemtosa	Musembe	Foxglove tree	Paulowniaceae	Exotic	Tree	Stomach problems Boils
Piper capense	Not established	Staart Pepper	Piperaceae	Indigenous	Shrub	Cough
Piper umbellatum	Indava	Cow-foot leaf	Piperaceae	Indigenous	Shrub	Head-ache and fever
Plectrantus forsteri	Shikhokho	Spur flower	Lamiaceae	Indigenous	Shrub	Worm infection in livestock
Prunus africana	Mwiritsa	Red Stinkwood	Rosaceae	Indigenous	Tree	Prostate cancer Stomach-ache

Scientific name	Local name	Common name	Family	Plant origin	Plant form	Diseases or conditions targeted
Rhus natalensis	Busanguli	Desert date	Anacardiaceae	Indigenous	Shrub	Worm infections in humans and livestock
Sapium ellypticum	Musasa	Jumping seed tree	Euphorbiaceae	Indigenous	Tree	Eye problems in livestock such as by injury or infection
Senecio moorei	Not established	Not established	Asteraceae	Indigenous	Shrub	Cough
Solanum incanum	Indalandalwa	Sodom Apple	Solanaceae	Indigenous	Shrub	Stomach-ache
Thunbergia alata	Indereresia	Black-eyed Susan vine	Acanthaceae	Indigenous	Shrub	Joint dislocation in both humans and livestock
Toddalia asiatica	Not established	Orange climber	Rutaceae	Indigenous	Shrub	Worms in cattle
Trichilia emetica	Munyama	Banket mahogany	Meliaceae	Indigenous	Tree	Fever Stomach-ache Sexually transmitted infections Malaria
Zanthoxyllum gilleti	Shikhoma	Not established	Rutaceae	Indigenous	Tree	Cough and chest complications associated with bacterial infection

Table 2. Families and corresponding number of species of medicinal plants identified.

Family	No of species	% proportion (N = 40)
Acanthaceae	2	5
Anacardiaceae	1	2.5
Apocynaceae	1	2.5
Asteraceae	4	10.3
Bignoniaceae	1	2.5
Ebenaceae	1	2.5
Euphorbiaceae	2	5
Fabaceae	4	10.3
Flacourtiaceae	1	2.5
Lamiaceae	4	10.3
Leguminoceae	1	2.5
Malvaceae	1	2.5
Melastomataceae	1	2.5
Meliaceae	2	5
Oleaceae	1	2.5
Paulowniaceae	1	2.5
Piperaceae	2	5
Ranunculaceae	1	2.5
Rosaceae	1	2.5
Rubiaceae	1	2.5
Rutaceae	2	5
Sapindaceae	1	2.5
Sapotaceae	1	2.5
Solanaceae	1	2.5
Verbenaceae	2	5

A number of diseases are treated by many medicinal species, reflecting the prevalence of those specific conditions in the community. These included diseases related to stomach upsets (12 species), boils (2 species), fevers and aches (5 species), diarrhea (3 species), colds and flu (2 species), worm infestation (3 species) and malaria (4 species).

The results of this study demonstrate that apart from the Kakamega forest's reputation as a significant Kenyan rainforest in terms of its rich biodiversity, eco-system service provision and as a remarkable tourist site[7,12–14], it is also important to the local community as a repository for ethno-pharmacological resources that play a crucial role in supplementing the government's effort in human and veterinary healthcare at the grass-root level, like the neighboring Nandi forest[9]. Much of the indigenous knowledge about these plant-based remedies is still held mainly by elderly members of the community. Furthermore, most knowledge holders tend to descend from families with long histories of the practice of traditional herbal healing.

In-depth discussions with the informants and a cross-section of some respondents among the local residents further revealed that even when the healers prescribe treatment to their patients, only the ready-made preparations are provided by the traditional healers meaning the patients would not be informed of the plant species from which the treatment is derived nor the method of preparation of the treatment. Nevertheless, this system is slowly changing and in recent years, some flexibility appears to be emerging, with the traditional healers, including the ones interviewed in this study, quite willing to provide information about the traditional treatments in exchange for financial inducement or compensation. For example, it is not uncommon to see young people hawking such easily used medicinal plants as *Mondia whytei* (see Table 1) along the streets of local urban areas. Such financial inducement was reported by the informants as a motivation for a growing crop of up-coming but semi-skilled traditional healers in the community.

Although this study was concerned with the wide variety of diseases treated using the medicinal plant species found in the Kakamega forest, the percentage proportions of medicinal plant types (shrubs, trees, herbs, climbers and lianas) is similar to that found by Jeruto *et al.*[25] who carried out a similar but narrower study in the Nandi forest for species used in treatment of malaria only. This latter study identified 40 medicinal plant species just like in our study, perhaps because of the larger spatial coverage of their study area.

In terms of plant parts used in treatment, leaves were predominantly used (Figure 3). This concurs with findings of a study in south-western Ethiopia[26] and in Morogoro, Tanzania[27], although these comparative studies were not carried out in forest habitats. However, it differs from findings of a similar survey conducted in the Mau forest, Kenya[11] and in Mt. Elgon[10], in both cases the use of roots was found to be predominant. One presumption for prominent use of leaves for treatments in Kakamega is that the destructive methods associated with root or bark harvesting, is restricted or not permissible or compatible with the conservation policies for the Kakamega[17] forest where most of the species are derived. Thus,

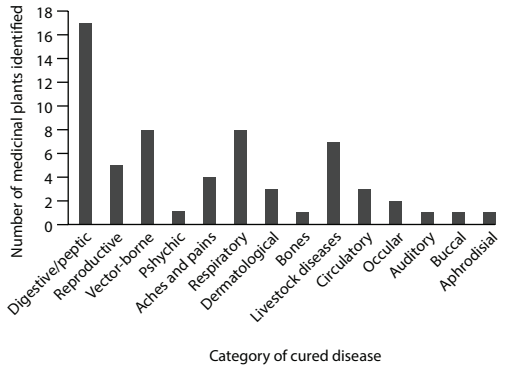

Figure 2. Overall distribution of categories of disease treated using medicinal plants recorded.

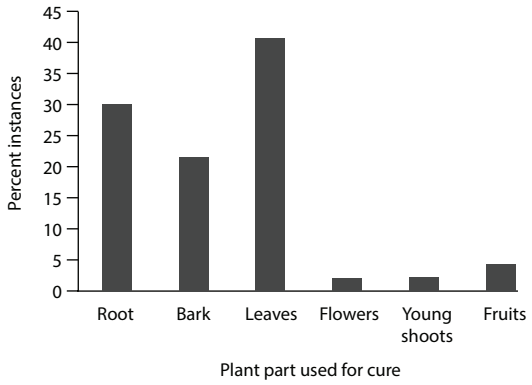

Figure 3. Percentage of use of the various parts of the medicinal plant species identified.

extracting leaves provides a more sustainable use strategy through rapid replacement by re-growth and is a practice acquired down the generations[28]. Leaves are also easier to harvest and prepare into various concoctions, decoctions or infusions such as an express juice for administration in treatment, than roots and bark. In addition, the preparation of various extracts from leaves ensures better preservation of the active ingredients of the medication, that in the case of other parts of the plant[10].

According to the respondents, most of the treatments are administered orally either as infusions, decoctions or concoctions. Similar results were obtained in another earlier study by Jeruto *et al.* in South Nandi forest specifically[9]. This appears to be consistent with the fact that most of them are used to treat diseases related to the digestive, oral tract or respiratory system (Figure 2). The high prevalence of digestive and respiratory-related diseases, compared to other afflictions, also appears to reflect relatively poor sanitation due to the high density of human population in the district (433 persons per kilometre[17]), an area that relies on only one main public healthcare facility, the Kakamega Municipal Hospital[29]. The mean distance is 10 km from patient-to-hospital and the doctor to patient ratio is 1:14,200. This is compounded by a poverty level of 52% and increasing levels of school drop-outs[29], implying correspondingly diminished knowledge about basic health and sanitation which are essential in managing such communicable digestive or respiratory diseases.

Conclusion

In conclusion, there is sufficient indigenous knowledge among the community around the Kakamega forest about medicinal plant species, to contribute not only to a sustainable provision of grass-root health care but also a potential to share this knowledge beyond western Kenya. Much of this knowledge is still held mainly by a few elderly people though financial inducements are said to be motivating a growing interest in the acquisition of knowledge among the wider community about these medicinal plants. This is encouraging because as the cost of conventional modern healthcare continues to increase, pushing such services out of reach to most rural dwellers in developing countries[30], there is a corresponding increased need to identify more affordable alternatives for the treatment of many ailments that affect rural populations. Unlocking such knowledge from the monopoly of a few to the wider population through an "accelerated" social construction[31] process such as through sustained public awareness campaigns, story telling or role plays, should thus be encouraged because such indigenous knowledge also has a potential for boosting economic empowerment of the local people through the sale of intellectual property rights or social capital. This may be leveraged further to boost conservation of such habitats from which medicinal plants are sourced, such as forests.

Recommendations

- More extensive excursions into the Kakamega forest and its immediate surroundings to reveal more medicinal plant species, particularly through the involvement of a larger number of key informants. Low numbers of informants were used because our study was constrained by time and logistical issues, thus not allowing us to cover the whole forest. As evident, the total number of medicinal plants identified is unexpectedly small in comparison, for instance, to similar areas such as the South Nandi forest[26]. Also it would be interesting to see if an equal number of male and female informants in the study might yield different knowledge perspectives such as the dominance of diseases of the alimentary canal and use of leaves over other medicinal plant parts, in the treatment of various diseases.
- A deliberate effort to make accessible results of earlier studies on medicinal plants of the Kakamega forest, anecdotal and otherwise, would make such knowledge more widely accessible to the wider public for use in the treatment of diseases. This could be through publishing, with technical review and support involving local and scientific stakeholders.
- Promotion of the use of natural remedies derived from various locally based resources such as medicinal plant species, should form an important priority of the Kenyan? governments' strategies to make healthcare accessible to rural populations in a more affordable way.

Author contributions

NO conceived the study and designed the experiments. Both authors were involved in data collection and interviews. NO prepared the first draft of the manuscript while both authors were involved in the revision of the draft manuscript and have agreed to the final content.

Competing interests

No competing interests were disclosed.

Grant information

Funds for the project were kindly provided by The Conservation Foundation in UK under its Young Scientist for Rainforests award scheme. The grant was awarded to Nickson Otieno. The grant had no grant number.

The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Acknowledgements

We wish to thank our three key respondents/informants Mr. John Shunza, Joel Mbogani and Femina Futa, the additional 4 opportunistically selected respodents as well as our interpreters Laban Shiundu, Patrick and Alphonse Ligaro for assistance with the location and identification of the medicinal plants and their uses; Kenya Wildlife Service (Buyangu, Kakamega) and Kenya Forestry Service (Isecheno Kakamega) for allowing us access to the forest to carry out the study; the local farmers on whose property some of the plants were encountered; the East African Herbarium staff for further assistance with plant identification; Helida Oyieke and Samuel Muchai for kindly reviewing the initial project proposal and finally Martin Potgieter and Hugo Asselin for reviewing the the first version of the article.

References

1. Berkes F: **Rethinking community-based conservation.** *Cons Biol.* 2004; **18**(3): 621–630.
Publisher Full Text
2. Biswas S: **Indigenous traditional knowledge integration for forest biodiversity conservation: Needs and priorities.** Paper submitted at the VII World Forestry Congress, 2003 Quebec Canada 2003.
Reference Source
3. Smith D, Pretty J: **Social capital in biodiversity conservation and management.** *Cons Biol.* 2003; **18**(3): 631–638.
Publisher Full Text
4. The Rainforest Foundation: **Indigenous knowledge.** The Rainforest Foundation. Accessed on 08/November/2012 2011.
Reference Source
5. Kala CP: **Aboriginal uses and management of ethnobotanical species in deciduous forests of Chhattisgarh state in India.** *J Ethnobiol Ethnomed.* 2009; **5**(20): 1–9.
PubMed Abstract | Publisher Full Text | Free Full Text
6. Ellen R: **Anthropological approaches to understanding the ethno-botanical knowledge of rainforest populations.** In: 'Tropical rainforest research: current issues', Edwards, D. S., Booth, W. B. and Choy, S. C. (eds). Kluwer: Dordrecht 1996; 457–465.
Reference Source
7. Beentje HJ: **Kenya Trees, Shrubs and Lianas.** National Museums of Kenya. Nairobi. 1994.
Reference Source
8. Kokwaro JO: **Medicinal Plants of East Africa (2nd.Ed.),** Kenya Literature Bureau of Kenya, Nairobi. Pp 35, 49, 69, 128, 158, 401 1993.
9. Jaruto P, Lukhoba C, Ouma G, *et al.*: **An ethnobotanical study of medicinal plants used by the Nandi people in Kenya.** *J Ethnopharmacol.* 2008; **116**(2): 370–376.
PubMed Abstract | Publishesr Full Text
10. Okello SV, Nyunja RO, Netondo GW, *et al.*: **Ethnobotanical study of medicinal plants used by Sabaots of Mt. Elgon Kenya.** *Afr J Trad CAM.* 2009; **7**(1): 1–10.
PubMed Abstract | Free Full Text
11. Ndegwa FK: **Use, conservation and harvesting of medicinal plants by the Ogiek people of East Mau forest, Nakuru district, Kenya.** Kenyatta University Library Online 2012.
12. Fashing PJ, Gathua JM: **Spatial variability in the vegetation structure and composition of an East African rain forest.** *Afr J Ecol.* 2004; **42**(3): 189–197.
Publisher Full Text
13. Otieno NE, Gichuki N, Farwig N, *et al.*: **The role of farm structure on bird assemblages around a Kenyan tropical rainforest.** *Afr J Ecol.* 2011; **49**(4): 410–417.
Publisher Full Text
14. Bennun AL, Njoroge P: **Important Birds Areas in Kenya.** East Africa Natural History Society, Nairobi, Kenya. 1999.
Reference Source
15. Bird Life International: **Important Bird Areas factsheet: Kakamega forest.** Accessed on 20/November/2012 2012.
Reference Source
16. Kokwaro JO: **Conservation status of the Kakamega Forest in Kenya: the easternmost relict of the equatorial rain forests of Africa.** *Mon Syst Bot Miss Bot Gard.* 1988; **25**: 471–489.
Reference Source
17. Akotsi EFN, Situma CA, Nzioka B, *et al.*: **Mapping land-use/land cover changes in Kakamega forest (1975–2005).** International Centre of Insect Physiology and Ecology and the Department of Resource Surveys and Remote Sensing. Nairobi, Kenya 2006.
18. Rietdorf U, Kappel R, Kaikai WO: **Linking local resources to SME development. A pathway out of poverty.** Project Report of BIOTA East Africa. Hamburg, Germany 2006.
Reference Source
19. Kothari CR: **Research Methodology: Methods and Techniques.** 2nd Edn. New Age International (P) Ltd. New Delhi, India 2000.
Reference Source
20. Badshah L, Hussian F: **People preferences and use of local medicinal flora in District Tank, Pakistan.** *J Med Plnt Res.* 2011; **5**(1): 22–29.
Reference Source
21. Kakamega Environmental Education Programme: **Plants of Kakamega forest.** Accessed 14/November/2012. 2012.
Reference Source
22. IUCN: **IUCN Red List of threatened species.** Version 2012. Accessed 09 November 2012 2012.
Reference Source
23. Takahashi T, Kokubo R, Sakaino M, *et al.*: **Antimicrobial activities of eucalyptus leaf extracts and flavonoids from Eucalyptus maculata.** *Lett Appl Microbiol* 2004; **39**: 60–64.
PubMed Abstract | Publisher Full Text
24. Cock I: **Medicnal plant images: Grevillea spp and Petalostigma pubescens.** *Pharmacognosy Communications* 2012; **2**(2): 78.
Publisher Full Text
25. Jeruto P, Mutai C, Ouma G, *et al.*: **An inventory of medicinal plants that the people of Nandi use to treat malaria.** *J Anim and Plnt Sc.* 2011; **9**(3): 1192–1200.
Reference Source
26. Yineger H, Yewhalaw D: **Traditional medicinal plant knowledge and use by local healers in Sekoru District, Jimma Zone, Southwestern Ethiopia.** *J Ethnobiol Ethnomed.* 2007; **3**(24): 24.
PubMed Abstract | Publisher Full Text | Free Full Text
27. Amri E, Kisangau DP: **Ethnomedicinal study of plants used in villages around Kimboza forest reserve in Morogoro, Tanzania.** *J Ethnobiol Ethnomed.* 2012; **8**(1): 1.
PubMed Abstract | Publisher Full Text | Free Full Text
28. Hughes D, DuMont K: **Using focus groups to facilitate culturally anchored research.** *Am J Community Psychol.* 1993; **21**(6): 775–806.
Reference Source
29. Kahuthu R, Muchoki T, Nyaga C (Eds.), *et al.*: **Kakamega District Strategic Plan.** Government of Kenya (Ministry of Planning and National Development). Nairobi. 2005.
30. Plaetse BV, Hlatiwayo G, Eygen LV, *et al.*: **Costs and revenue of health care in a rural Zimbabwean district.** *J Health Pol Plann.* 2005; **20**(4): 243–251.
PubMed Abstract | Publisher Full Text
31. Lee Y: **Indigenous knowledge construction and experimental learning of Taiwanese aborigines.** *Intern Ed Stud.* 2009; **2**(2): 155–161.
Reference Source

Current Referee Status:

Referee Responses for Version 2

Martin Potgieter
Department of Biodiversity, University of Limpopo, Sovenga, South Africa

Approved: 09 January 2013

Referee Report: 09 January 2013
I have reviewed the revised manuscript Local indigenous knowledge about some medicinal plants in and around Kakamega forest in western Kenya. I now find the manuscript in order, and I am satisfied that the authors have addressed all my previous reservations regarding this paper. I hereby now approve this paper.

I have read this submission. I believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Competing Interests: No competing interests were disclosed.

Hugo Asselin
Sciences du développement humain et social, Université du Québec en Abitibi-Témiscamingue, Québec, Canada

Approved: 17 December 2012

Referee Report: 17 December 2012
I am satisfied with how the authors have modified the manuscript according to my suggestions.

A few typos remain here and there, but apart from that, I have nothing left to say. This is an interesting descriptive study that hopefully is just a first step towards a more complete and more thorough publication.

I have read this submission. I believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Competing Interests: No competing interests were disclosed.

Referee Responses for Version 1

Hugo Asselin
Sciences du développement humain et social, Université du Québec en Abitibi-Témiscamingue, Québec, Canada

Approved with reservations: 17 November 2012

Referee Report: 17 November 2012
This is an interesting piece of work, although very incomplete. I actually hesitated between recommending acceptation or rejection, but decided to settle on the former because any new contribution on traditional knowledge related to medicinal plants should be welcomed. However, I do have several important concerns to raise about this article.

First, it should be made very clear that the study is based on the knowledge of only 3 respondents. Each of them might know a lot, but they still are just 3 respondents. Completely different results altogether could have been obtained by interviewing 3 other respondents.

Second, it is hard to evaluate the actual contribution of the study to the scientific knowledge, as no other study on traditional knowledge related to medicinal plants in Kenya or tropical Africa is cited. A quick search in Web of Science shows that 87 papers were published in the last 15 years for Kenya alone.

Third, more details should have been provided about the forests in which sampling took place. Calling them tropical is not enough. Information on species richness, for example, would have been needed to appreciate if the 40 species recorded as medicinal plants form a significant or trivial proportion of the complete species set. In addition, dominant species and forest dynamics should have been provided to facilitate comparison with other studies. Also, the choice of the forest blocks where sampling took place should have been justified.

Fourth, information should have been provided about how ethical issues were addressed. Traditional knowledge is a sensible topic (even the more so when it relates to medicinal plants) and a precautionary approach should be taken to ensure protection of intellectual property rights.

Fifth, the choice of the 3 respondents should have been explained in more details. Why only 3? Why these 3? Were they men or women? Knowledge is not shared equally between genders. Etc.

Other comments:

- The abstract is too general and does not provide all the relevant results.
- The English should be checked by a native speaker. Some sentences are awkward, some words are missing, and some words are uselessly repeated.
- Figure 1 does not show the effect of forest fragmentation, so the first paragraph of the “Study area” section should not imply that.
- Why wasn’t BirdLife International (2004) added to the reference list and cited properly?
- Population density should be given as a number of people per SQUARED kilometers.
- “Salaza” is not shown on Fig. 1.
- Please make clearer the distinction between “block”, “fragment”, “section”, etc.
- Herbarium voucher numbers should be provided, or, at least, the name of the herbarium where samples are kept should be given.
- A total of 40 medicinal plant species seems low. How does it compare with other studies in African tropical forests?
- Why use quotation marks when writing “cure”? This uselessly sheds a doubt on the efficacy of medicinal plants.

- I am surprised that none of the species (especially herbs) was used entirely (instead of just leaves, or fruits, or other parts).
- How were the disease classes chosen? The “vector-borne” class is not a type of disease, but rather a way of transmission. It can include digestive, psychic, or other types. Furthermore, several common ailment categories were not reported to be treated with medicinal plants. Explanations should have been provided as to why. Authors should have followed, for example, Cook’s (1995) classification : Cook FEM (1995) Economic Botany Data Collection Standard. Kew: Royal Botanic Gardens.

I have read this submission. I believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Competing Interests: No competing interests were disclosed.

1 Comment

Author Response

Nickson Otieno, National Museums of Kenya, Kenya
Posted: 14 Dec 2012

Dear Dr. Asselin,

Thank you for your review. We have made the following changes in light of your comments.

Choice of respondents: We have now made it clear that there were 3 main focal respondents but that there were 2 other opportunistic random respondents that provided additional information for the study in each forest block, making a total of 9 respondents. Such selection was based on prior consultation with local community leaders and additional guidance by field assistants. Since this study was not meant for gauging opinions, we did not set out to interview as many respondents as possible. That is why we state that we had a key focal group of respondents chosen for their knowledge about the same, and of a minimum age that is generally recognized globally to posses the greatest of such knowledge. One of our key respondents was a practicing healer with long experience in the practice.
Consultation of existing literature on the subject, in Kenya: We have incorporated more references to the literature in the revised version.
Ethical issues in data use: Prior consent was obtained from each informant before information was obtained including information that the data would be shared widely. All respondents were duly acknowledged in the manuscript and are publicly acknowledged in the final publication. A condition for publication of the manuscript was to provide the detailed data so it was not optional not to disclose the full dataset of all the medicinal plants in detailed form.Abstract too general: We have now provided more details about the results in the abstract.Grammatical errors etc: More careful revision has been made in this regard including in-house pre-review by experienced authors.
Figure 1 not related to fragmentation: The reference to Figure 1 is now placed in a more explicitly relevant part of the paragraph.
BirdLife International reference: A more recent reference has now been included.Population

density unit: This is now provided (in per square kilometers).
Block/fragment/section: This is now clarified as referring to forest blocks.
Herbarium vouchers: The plant specimens that were collected were not part of herbaria specimens and so did not have voucher numbers. They are yet to be curated and catalogued as the EA Herbarium in Nairobi is rather short of space for replicate specimens.
Total of 40 medicinal plants: This number of species identified has now been put in perspective by comparing with other studies elsewhere in Kenya.
Quotation marks on "cure": The term "cure" has been replaced with "treatment" which we feel is more appropriate.
I am surprised that none of the species (especially herbs) was used entirely (instead of just leaves, or fruits, or other parts: In Table 1, a number of plants for which more than one part is used for treatment is provided.
Choice of classification of disease: The diseases were classified mainly on the basis of the parts of the body that are affected. Obviously this does not apply for "vector-borne" and "livestock" but the idea about including the former was to highlight such vector transmitted diseases, which are common in the area, such as malaria, which would otherwise easily be subsumed by the other classes since malaria presents with a multitude of symptoms. For "livestock" diseases, again this was to highlight them as non-human and compare them with the non-human ones.More details about the forest: We have now added more details in describing Kakamega forest where the study was carried out, including floral and other species status, and the overall vegetation structure.
Selection of blocks: We have described the rationale for the choice of forest blocks.
Competing Interests: No competing interests were disclosed.

Martin Potgieter
Department of Biodiversity, University of Limpopo, Sovenga, South Africa

Approved with reservations: 06 November 2012

Referee Report: 06 November 2012
This is potentially a very interesting article, and I think it could ultimately make a positive contribution to the evidence base. However, this paper has a number of serious flaws.

More information and detail required:
- The abstract and results are superfluous and do not report on some of the major findings.
- More can be made of the data in figure 4. Why, for example, are leaves so much used, when in the rest of Africa roots are being predominantly used?
- The information from figure 3 is not reported in the results or discussion. For example it would be interesting to know why digestive was so much treated.

Discussion, conclusion and recommendations:
- The discussion focuses most on generalities and not specifics as is found in the results.
- Data on methods of preparation, administration, age and gender are not reflected in the results and discussion. This is particularly important for gender as the level of knowledge of local/rural African communities vary. Women are generally more knowledgeable in local households, but men are more knowledgeable when they are traditional healers.
- References are seriously lacking in the discussion – thus no scientific authority is applied to most of the statements presented here. Thus this discussion is basically just an opinion.

- Some parts of the discussion need rearranging to either the results (end of 2nd paragraph) or the conclusion (3rd paragraph).
- Significant tracts of the discussion do not appear to be relevant to the study at hand, particularly the last two paragraphs of the discussion; the authors should consider removing these.
- The current conclusion does not address the core data of this manuscript.
- The authors should provide reasons for the points made in the 'Recommendations' section.

Inconsistencies:
- Questionnaires: In the abstract and main text it is implied that multiple questionnaires are used but only one is provided.
- It says in the sampling strategy that experience as a herbalist was not essential, yet in the discussion it states that indigenous medicinal knowledge is a closely guarded only passed to family members. It would have been worthwhile to know the ratio of interviewed traditional healers/practitioners vs. lay people – there is a significant difference in their level of knowledge.
- In the discussion the authors state that indigenous knowledge is confined to mainly the elderly but this study targeted only people above 50. In Africa that constitutes the elderly. Thus we have no data on the knowledge level of people younger than 50. Therefore we have no data to backup this statement.

Language:
- Some attention to the accuracy of language used is required; some words need removing, the authors should define what they mean by 'key species' (abstract) and appreciable knowledge (page 2) and replace the term 'cured' with 'treated'.

Notes on plant family classification:
- *Bequartiodendron oblanceolata* is from the Sapotaceae family.
- Malvaceae is the correct family name for *Hibiscus spp*; Malvoideae is a subfamily.

I have read this submission. I believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Competing Interests: No competing interests were disclosed.

1 Comment

Author Response

Nickson Otieno, National Museums of Kenya, Kenya
Posted: 14 Dec 2012

Dear Dr. Potgeiter, Thank you for your review.

We have made the following changes in light of your comments.

Title: We have added the word "some" in the title to preclude the presumption that we sought to list all medicinal plants from Kakamega forest in the one survey.Abstract: We have restructured and re-written the abstract to reflect suggested changes. We have also clarified that we used one structured questionnaire and not many types of questionnaire.

Introduction: We have cited two references as suggested to support our assertion about other studies having been conducted on the subject.

Materials and methods: We have corrected the indicated errors and have also specified how respondents were selected, including the proportions of practitioner to lay respondents, and key to random respondents.

Data analysis: Suggested errors now corrected.

Results: *Bequartioden¬dron oblanceolata* is now assigned to the family *Sapotaceae* as has been helpfully noted by the reviewer. The reference for IUCN is now provided. The word “cure” is now replaced by “treatment”. We have also provided a clarification on methods of administering medicinal plants other than orally.

Discussion: We have now merged the Results with the Discussion under the new heading “Results and discussion” to make a more lucid connectivity between the two. In table 1, the Malvoidae subfamily is now corrected to *Malvaceae* family, as informed by the reviewer. The original Figure 2 depicting proportions of medicinal plant forms is now removed to avoid repeating results in text. As a result, Figure 3 becomes Figure 2 and Figure 4 becomes Figure 3. Figure 2 (new) is now reported in the text of results and discussion, together with an expoundment on the predominance of digestive-related diseases treated using the medicinal species. The new Figure3 now bears, in text, discussion as to the predominance of the use of leaves for treatments, viz-a-viz other plant parts. Table 2 is corrected as suggested; parts of the discussion suggested as not strongly related to the core data and results by reviewer, have been removed. The link between access to information on medicinal cures by local and improvement of basic healthcare is now more clearly explained. The conclusion is now more closely tied to the results of the study. Recommendations are now better justified.

References: Corrections on the original reference number 12 is now effected; Due to additional references (also reflected in the body text) the reference section has now been reorganized accordingly.
Competing Interests: No competing interests were disclosed.