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Medicinal plants used to treat the most frequent diseases encountered in Ambalabe rural community, Eastern Madagascar

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Abstract

Background: Traditional medicine remains the only health care available in many rural areas in Madagascar like the rural community of Ambalabe, located in a very remote area in the eastern part of the country. With limited access to modern medicine, the local population uses medicinal plants to treat most diseases. In this study, we aimed to inventory medicinal plants used by local people and how those relate to the treatment of the most frequent diseases encountered in Ambalabe.

Methods: We interviewed participants in order to identify the most frequent diseases in the region and the medicinal plants used to treat them. The local physician was asked about the most frequent diseases, and ethnobotanical surveys to record medicinal plants and their uses, using semi-structured interviews and free listing, were conducted among 193 informants in local villages, of which 54 % were men and 46 % were women, ageing from 16 to 86 years. The local names, the uses of each plant species and the way they are prepared and administered were recorded and accompanied by herbarium specimens for identification. We also interviewed four traditional healers to elicit more details on the preparation and the use of plants.

Results: Our research allowed us to identify six most frequent diseases, namely diarrhea, malaria, stomach-ache, cough, bilharzia and dysentery. Among 209 plant species identified as having medicinal use, 83 species belonging to 49 families and 77 genera were used to treat these diseases. Our analyses highlighted the 11 commonly used species for their treatment, and also 16 species with a high fidelity level (FL ≥ 75 %) for each ailment. Diarrhea is one of the diseases with high number of species recorded.

Conclusions: This study highlighted the closed relationship between people in Ambalabe and plant species, especially when faced with frequent diseases. However, most of the species used were collected in the surroundings of the villages. Few species were from Vohibe forest in which a management system on the use of plant species was already established. Therefore, a sustainable use management should be considered for wild species from which medicinal plants are highly abundant.

Keywords: Medicinal plants, Madagascar, Ethnobotanical surveys, Frequent diseases, Conservation

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Background

Traditional medicine has been used by the majority of the world population for thousands of years [1]. The World Health Organization (WHO) reported that an estimated 80% of the population in developing countries depend on traditionally used medicinal plants for their primary health care [2]. It is particularly the case in the rural and very remote area like the community of Ambalabe, in the Eastern part of Madagascar. In this area, sanitary conditions are very underdeveloped. A Basic Health Centre (Centre de Santé de Base or CSB) level II was established in the centre of the community (Ambalabe), with only a single doctor present 15 days per month. Thus, people resort to self-medication by buying drugs from peddlers, or prefer to use traditional medicine, which is often the only accessible and affordable remedy [3–5], and often associated with poverty [6].

People in Ambalabe community generally use plants for healing, and traditional healers are often consulted [7]. Medicinal plants are collected either in the surroundings of the villages, or in Vohibe forest which belongs to the community. Unfortunately, natural resources in Madagascar, including medicinal plants, are clearly affected by biodiversity loss, environmental degradation and a lack of sustainable harvesting practices [7–10]. These impacts are also exacerbated by climate change, and high levels of poverty [11].

Rapid deforestation and slash and burn cultivations (tavy) are threats that often affect medicinal plant habitat in the Eastern part of Madagascar [12], which may affect people’s knowledge related to the use of medicinal plants. Furthermore, knowledge on these plants in Ambalabe community is still hardly documented at all. Only one paper addressed the issue on medicinal plants known by men [7], and knowledge erosion is currently observed worldwide [13, 14]. A lack of written documentation for Ambalabe community also adds to this problem, like shown in other countries [15]. Thus, this research was conducted with the aims to understand the importance of plant species as remedies, to document the knowledge on their uses among the local population especially when faced with frequent diseases, and to assess the degree of threats on those medicinal plants. To achieve our goals, we aimed to identify the most frequent diseases encountered in Ambalabe, and to inventory the medicinal plants used for their treatment and how they are used. Locations where these species were collected were recorded to find the number of species occurring in the local protected area. Our hypotheses were that (1) the local population has an important knowledge on plant species used to treat the most frequent diseases, and (2) most of medicinal plants are found in the surroundings of the villages and might be threatened by unsustainable collection and harvest practice. We focused on medicinal plants cited for the most frequent ailments and the area where they were collected.

Methods

The research was conducted with the contribution of the local staff of the Missouri Botanical Garden and the local population. To increase our understanding on traditional knowledge and the importance of plant remedies, fieldwork was carried out for 20 days in March 2011 with the aim to identify the most frequent diseases occurring within the Ambalabe community, and to conduct an ethnobotanical survey among the local population. We included four traditional healers to ensure the consistency of information on the use of plants in traditional medicine [16].

Study Site and its surroundings

The rural community of Ambalabe covers an area of 17437 ha and is located 72 km northwest of the district capital of Vatomandry, which is the nearest large city and marketplace, in Eastern Madagascar [17]. The community is subject to a humid tropical climate [18], with an average annual rainfall of 1773 mm and an average annual temperature of 24 °C. Infrastructure decay (disrepair of roads and bridges) led to the isolation of the community and made markets and healthcare options less accessible. The road is only passable in the dry season by 4x4 vehicles up to 46 km from Vatomandry. Moreover, the local CSB II cannot meet the demand for medical care of the population given its remoteness from some villages. The rough topography of the area also makes access more difficult. Therefore, people often consult traditional healers instead of doctor.

Ambalabe had 10961 residents in 2013, of which 95% were farmers (mayor of the rural community of Ambalabe, personal communication). Local inhabitants are mainly Betsimisaraka, for whom shifting cultivation forms the base of their agriculture system [19]. This practice leads to the loss of natural forest [20], including the natural pharmacopeia.

A New Protected Area, Vohibe forest was established in the community in 2008. Vohibe is a humid and evergreen forest of low and medium altitude. It provides to the local population their daily needs such as timber, firewood, medicinal and edible plants. The forest is regularly subjected to Madagascar’s in general [22]. At the end of 2014, near
723 species distributed in 113 families and 293 genera were inventoried in Vohibe forest, and near 854 species belonging to 133 families and 355 genera in the whole Ambalabe community, including Vohibe [23].

Ethnobotanical surveys
Before the surveys, meetings with local authorities, leaders and villagers, were organized to explain the goals of the study and to obtain their prior informed consent [24], based on the Nagoya protocol’s rules [25]. All participants were also asked for their prior informed consent before starting interviews. The University ethics commission also approved the study. A collection permit n° 160/11/MEF/SG/DGF/DCB.SAP/SCBSE for plants was also presented to the local authorities.

In this study, semi-structured interviews and free listing exercise [26] were conducted among local villages in order to identify the most frequent diseases encountered in the Ambalabe community, and to inventory medicinal plants used by the local population, together with their local names, detailed use information such as parts used and the way to prepare and to administer plant remedies, and also the area of collection. Surveys were also conducted with the local doctor and the four traditional healers. Figure 2 gives the number of informants (apart from the local doctor) according to their occupation. In total, 193 informants from 16 to 86 years old were interviewed, of which 54 % were men and 46 % were women. Most of them are farmers.

![Fig. 1](image1.jpg)

**Fig. 1** The rural community of Ambalabe and Vohibe forest, in Vatomandry District, eastern Madagascar

![Fig. 2](image2.jpg)

**Fig. 2** Number of informants interviewed according to their occupation
Questionnaires were used as a guide to collect information during the surveys (Additional file 1). Thirteen representative villages of the whole community were visited. The local staff helped us to identify them. Interviews were conducted with both individuals and in group by the first author in Betsimisaraka, the local Malagasy dialect. One local healer acted as a guide and translator if necessary. Plant uses were categorized according to Cámara-Leret et al. [27]. Within the Medicinal and Veterinary category, the following use subcategories were adopted in this study: blood and cardiovascular system; cultural diseases and disorders; dental health; digestive system; endocrine system; general ailments; infections and infestations; metabolic system and nutrition; muscular-skeletal system; nervous system and mental health; poisoning; pregnancy, birth and puerperium; reproductive system and reproductive health; respiratory system; sensory system; skin and subcutaneous tissue; urinary system; veterinary; other.

Local MBG staff has conducted floristic collections in the region since 2004, and has established a reference collection. Given the limited time in the field, common species were directly identified by the local staff in comparison to the reference collection. All species not previously collected for the floristic study were collected and photographed for identification and vouchers were deposited primarily in the national herbarium of the Parc Botanique et Zoologique de Tsimbazaza (TAN). Available duplicates were distributed to the herbaria of Missouri (MO) and the Muséum National d'Histoire Naturelle (P) in Saint Louis and Paris. For common or cosmopolitan plants (for example fruit trees and tropical weeds) found worldwide, vouchers were not collected. For some plant species cited by informants but not encountered during the fieldwork, a brief description of the plant species was taken. Then, the scientific names were elucidated according to the herbarium and traditional healers' knowledge, and then simple informants and traditional healers' knowledge on medicinal plants used to treat the most frequent diseases. Kruskal-Wallis test was also used for the age and marital status categories.

**Statistical analysis**

ANTHROPAC® 4.0 [28] and XLSTAT®-Pro 7.5 were used for statistical data analyses. ANTHROPAC®, a set of programs using various techniques of collecting “systematic” data [29], was used to analyze the free listing data from which the results were expressed as frequency of citation (%) and salience (a value that lies between 0 and 1). In this study, frequency is considered as the repetition of citations during the surveys, of which one species related to one specific use of one plant part by one informant is counted as one citation. Salience is a statistic accounting for rank and frequency of species cited [30] in which one species is considered more salient when it appears more often and earlier in freelists.

Species that are frequently cited are assumed to be highly salient, i.e. important to respondents, and species recalled first are assumed to be more salient than species recalled last [31]. Most frequent and most salient species are then considered important for the local population. Mann–Whitney test at alpha 0.05, performed through XLSTAT®-Pro, was used in order to assess the difference between men and women's knowledge, and then simple informants and traditional healers' knowledge on medicinal plants used to treat the most frequent diseases. Informant consensus was also used for the age and marital status categories.

**Informant consensus**

Another consensus method, which is the fidelity level (FL), was used to quantify the importance of a species for a given disease [32–34]. It calculates a ratio between the number of informants who cited the species for a particular disease ($I_p$) and the total number of informants that cited the plant for any given disease ($I_a$). Formula used was:

$$FL = \frac{I_p}{I_a} \times 100\%$$

For the analysis, species with $FL \geq 75\%$ were considered as the most relevant for the treatment of a specific disease. However, species only cited once for one ailment, i.e. infrequently cited species, were left out of the analysis.

**Results**

In the 13 villages visited, 193 people were interviewed. Of these 89 (46%) were women and 104 (54%) were men, ageing from 16 to 86 years. About 49% of the participants cited frequent diseases encountered in the Ambalabe rural community. Out of 209 species recorded as having medicinal use, belonging to 83 families and 179 genera, 83 species were used to treat the most frequent diseases.

**Informants' knowledge**

Our investigations recorded 73 types of illness. The most important of them affect mainly the digestive, the reproductive and the respiratory system. Six of these diseases (diarrhea, malaria, stomach-ache, cough, bilharzia and dysentery) were identified as the most frequent ailments in the Ambalabe community. Local people used 83 different plant species belonging to 49 families and 77 genera to treat these six afflictions, i.e. an average of 17 species for each of them. Seventy-seven species were identified to species level and 29% were endemic. About 23% of the 83 species are known by at least ten informants. Sixteen species were used to treat more than one ailment. The number of species used for each disease is shown in Table 1. Most of the species were used to treat
diarrhea and stomach-ache. Fewer medicinal plants were used for bilharzia and dysentery treatment. People often consulted a doctor for these two serious ailments. Table 2 gives the informants’ knowledge according to demographic variables. Men cited more plant species as used than women. This might be a residual effect of the higher number of male informants interviewed. However, when analyzing the average number of species cited by each informant in relation to gender, a Mann–Whitney test showed that men held more knowledge than women, with $P = 0.01 < 0.05$. This difference is significant. Men were also the only informant group who cited all six species used to treat bilharzia. Within the age and marital status categories, the difference on plant species cited is not significant with respectively $P = 0.6$ and $P = 0.9$. However, it should be noted that the single widowed informant had an important knowledge by citing nine species, nearly two species for each of the four ailments he cited.

When comparing traditional healers and simple informants’ knowledge on plant species used to treat the most frequent diseases, a Mann–Whitney test showed that no significant difference was found concerning their knowledge ($P = 0.8 > 0.05$). This means that both informant groups cite almost the same amount of plants (an average of two species per ailment) used to treat each disease. However, cited plant species were different according to the informant, which explains the high number of plants recorded (83 species) for the six ailments.

Therefore, difference was only found among the gender setting. No difference was found between traditional healers and simple informants’ knowledge, which means that the more these diseases are frequent, the more people get to know plant species used to treat them. As such, the local population did often not consult traditional healers or the local doctor except for treating bilharzia and dysentery for which few plants are known as effective, and which are considered as diseases with high risk of complications.

**Frequent diseases and medicinal plants used**

A free listing analysis highlighted the 11 plant species most commonly used for the treatment of five of the six frequent diseases, with a frequency higher than 5% (Table 3). Three of them (*Kalanchoe prolifera*, *Paederia thouarsiana*, *Catharanthus roseus*) are endemic to Madagascar, six (*Mollugo nudicaulis*, *Litchi chinensis*, *Rubus moluccanus*, *Petchia erythrocarpa*, *Harungana madagascariensis*, *Aeschynomene sensitiva*) are not endemic and two (*Psidium guajava*, *Clidemia hirta*) are naturalized. The most important were *Mollugo nudicaulis*, *Litchi chinensis*, *Kalanchoe prolifera* and *Paederia thouarsiana* with more than 10% of frequency. *Mollugo nudicaulis* was the most frequent as well as the most salient species used, thus assumed to be important for the local population. Leaves were the most important plant part used for treatment. Remedies were basically prepared as decoction, which was administered orally.

None of the top eleven species was used for bilharzia treatment. However, six different species were specifically

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**Table 1** Number of species which treat the six frequent diseases in the Ambalabe rural community

| Diseases     | Number of species used |
|--------------|------------------------|
| Bilharzia    | 6                      |
| Cough        | 14                     |
| Diarrhea     | 32                     |
| Dysentery    | 6                      |
| Malaria      | 13                     |
| Stomach-ache | 30                     |

**Table 2** Informants’ knowledge in the Ambalabe rural community according to demographic variables

|                  | Total number of people interviewed | Number of informants who cited frequent diseases | Number of diseases cited (not cited) | Total of species cited | Percentage of total |
|------------------|-----------------------------------|-----------------------------------------------|-----------------------------------|-----------------------|---------------------|
| Gender           |                                   |                                               |                                   |                       |                     |
| Men              | 104                               | 58                                            | 6                                 | 68                    | 82                  |
| Women            | 89                                | 36                                            | 5 (bilharzia)                     | 45                    | 54.2                |
| Age group        |                                   |                                               |                                   |                       |                     |
| [16–25]          | 43                                | 15                                            | 6                                 | 22                    | 26.5                |
| [26–35]          | 38                                | 20                                            | 6                                 | 28                    | 33.7                |
| [36–45]          | 44                                | 25                                            | 6                                 | 37                    | 44.6                |
| [46–55]          | 34                                | 21                                            | 6                                 | 40                    | 48.2                |
| [56–65]          | 20                                | 9                                             | 6                                 | 26                    | 31.3                |
| [66+]            | 14                                | 4                                             | 4 (bilharzia, dysentery)          | 4                     | 4.8                 |
| Marital status   |                                   |                                               |                                   |                       |                     |
| Single           | 30                                | 13                                            | 4 (bilharzia, dysentery)          | 16                    | 19.3                |
| Married          | 152                               | 76                                            | 6                                 | 78                    | 94                  |
| Divorcee         | 7                                 | 4                                             | 4 (bilharzia, stomach-ache)       | 7                     | 8.4                 |
| Widowed          | 4                                 | 1                                             | 4 (cough, malaria)                | 9                     | 10.8                |
### Table 3: Eleven most common species used to treat frequent diseases in the Ambalabe rural community

| Family          | Scientific name                        | Local name (dialect: Betsimisaraka) | Diseases treated                                      | Parts used | Preparation method  | Administration | Frequency (%) | Salience (%) | Voucher number |
|-----------------|----------------------------------------|-------------------------------------|------------------------------------------------------|------------|---------------------|----------------|---------------|--------------|----------------|
| Molluginaceae   | Mollugo nudicaulis Lam.                | Aferotany                          | Malaria, stomach-ache                               | Whole plant| Decoction, infusion | Oral           | 21.3          | 0.15          | RKN 485        |
| Sapindaceae     | Litchi chinensis Sonn.                 | Letisia                            | Diarrhea, dysentery, stomach-ache                   | Bark, Leaves| Decoction           | Oral           | 12.8          | 0.1           |                |
| Crassulaceae    | Kalanchoe prolifera (Bowie ex Hook.)  | Sodifafana                         | Cough, malaria                                      | Leaves     | Decoction, heat and press the juice | Oral           | 11.7          | 0.08          | RKN 512        |
| Rubiaceae       | Paederia thouarsiana Baill.            | Vahivola, vahimantsina             | Stomach-ache                                        | Branch, leaves | Decoction       | Oral           | 10.6          | 0.08          | RA 1349        |
| Apocynaceae     | Catharanthus roseus (L.) G. Don        | Arivotaombelona                    | Malaria                                             | Leaves     | Decoction           | Oral           | 7.4           | 0.03          | RKN 503, 504   |
| Rosaceae        | Rubus moluccanus L.                    | Takoaka                            | Diarrhea, dysentery                                 | Leaves     | Crush, decoction    | Oral           | 7.4           | 0.07          | REH 720        |
| Myrtaceae       | Psidium guajava L.                     | Gavo, gavombazaha, gavobe          | Diarrhea, dysentery                                 | Bark, leaves| Decoction           | Oral           | 7.4           | 0.06          | RCS 456        |
| Melastomataceae | Clidemia hirta (L.) D. Don             | Sompatra                           | Diarrhea, malaria, stomach-ache                     | Leaves, roots | Decoction, inhalation, oral | Oral           | 6.4           | 0.06          | RKN 513        |
| Apocynaceae     | Petchia erythrocarpa (Vatke) Leeuwenb. | Hintona                            | Malaria                                             | Bark, leaves| Decoction, infusion | Oral           | 6.4           | 0.05          | RKN 453        |
| Hypericaceae    | Harungana madagascariensis Lam. ex Poir.| Harongana                          | Diarrhea                                            | Bark, leaves| Decoction           | Oral           | 6.4           | 0.03          | RA 1325        |
| Fabaceae        | Aeschynomene sensitiva Sw.             | Fanombo tintina                    | Malaria                                             | Leaves     | Decoction           | Oral           | 5.3           | 0.05          | RKN 523        |

### Table 4: Relevant species with high fidelity level used per disease category

| Disease          | Relevant species                        | Distribution  | Number of citations | FL |
|------------------|----------------------------------------|---------------|---------------------|----|
| Bilharzia        | Senna alata (L.) Roxb.                 | Naturalized   | 2                   | 100|
| Cough            | Citrus limon (L.) Burm. f.             | Naturalized   | 3                   | 100|
|                  | Oxalis corniculata L.                  | Naturalized   | 3                   | 100|
| Diarrhea         | Artocarpus heterophyllus Lam.          | Not endemic   | 4                   | 100|
|                  | Canarium L.                            | Endemic       | 4                   | 100|
|                  | Raphia fannifera (Gaertn.) Hyl.        | Naturalized   | 4                   | 100|
|                  | Danaus terminalis Boivin ex Drake     | Endemic       | 3                   | 100|
|                  | Macaranga obovata Boivin ex Baill.     | Endemic       | 3                   | 100|
|                  | Musa paradisiaca L.                    | Not endemic   | 3                   | 100|
|                  | Psidium cattleyanum Sabine             | Naturalized   | 3                   | 100|
|                  | Maesa lanceolata Forssk.               | Naturalized   | 2                   | 100|
|                  | Manihot esculenta Crantz               | Not endemic   | 4                   | 80 |
| Malaria          | Catharanthus roseus (L.) G. Don        | Endemic       | 7                   | 100|
|                  | Aeschynomene sensitiva Sw.             | Not endemic   | 5                   | 83 |
| Stomach-ache     | Cyanthillium cinereum (L.) H. Rob.     | Not endemic   | 2                   | 100|
|                  | Paederia thouarsiana Baill.            | Endemic       | 10                  | 77 |
| Family           | Scientific name | Local name | Diseases treated | Part used       | Preparation | Administration | Number of citations | FL   | Voucher     |
|------------------|-----------------|------------|------------------|-----------------|-------------|----------------|---------------------|------|-------------|
| Anacardiaceae    | Sorindeia madagascariensis DC. | Voasirindrina | Diarrhea          | Leaves          | Decoction   | Oral           | 3                   | 27   | RA 1334     |
|                  |                  |            | Stomach-ache     | Leaves          | Decoction   | Oral           | 1                   | 9    |             |
| Annonaceae       | Annona muricata L. | Voatsokina, goronoa | Stomach-ache     | Leaves          | Decoction   | Oral           | 1                   | 50   | CR 4242     |
| Aphloiacae       | Aphloia thelformis (Vahl) Benn. | Fandramanana | Stomach-ache     | Leaves          | Decoction   | Oral           | 1                   | 17   | RA 1335     |
| Apiaceae         | Centella asiatica (L.) Urb. | Talapetraka | Stomach-ache     | Leaves          | Decoction   | Oral           | 1                   | 100  | RNH 545     |
| Apocynaceae      | Catharanthus roseus (L.) G. Don | Arivotaombelona | Malaria          | Leaves          | Decoction   | Oral           | 7                   | 100  | RKN 503, 504|
|                  | Petchia erythrocarpa (Vatke) Leeuwenb. | Hintonama | Malaria          | Leaves          | Decoction   | Oral           | 6                   | 33   | RKN 453     |
| Areaceae         | Cocos nucifera L. | Coco       | Diarrhea          | Leaves          | Infusion    | Oral           | 1                   | 50   | Gunn 643    |
|                  |                  |            | Stomach-ache     | Leaves          | Decoction   | Oral           | 1                   | 50   |             |
| Asteraceae       | Cyanthillium cinereum (L.) H. Rob. | Ramisiry | Stomach-ache     | Whole plant     | Decoction   | Oral           | 2                   | 100  | AP 4968     |
|                  | Elephantopus scaber L. | Angadoha  | Diarrhea          | Leaves          | Crush and heat | Oral           | 1                   | 14   |             |
|                  |                  |            | Stomach-ache     | Leaves          | Heat and press | Oral           | 2                   | 29   |             |
| Ermilia citrina DC. |                  | Tsihontsionina | Malaria          | Whole plant     | Decoction   | Oral           | 2                   | 22   | RKN 448     |
|                  |                  |            | Stomach-ache     | Leaves          | Decoction   | Oral           | 2                   | 22   |             |
| Heliandus annuus L. |                  | Tanatanamazoandro | Malaria          | Leaves          | Infusion, decoction | Oral           | 3                   | 38   |             |
| Burseraceae      | Canarium L. |                  |                  |                  |            |                |                    |      |             |
| Clusiaceae       | Garcinia chopetleri (Planch. & Triana) H. Perrier | Takasina | Cough             | Leaves          | Decoction   | Oral           | 1                   | 100  | RKN 473     |
|                  | Symphonia fasciculata (Noronha ex Thouars) Verque | Kijy        | Diarrhea          | Bark            | Decoction   | Oral           | 1                   | 100  | RAB 66      |
| Combretaceae     | Combretum Loefl. | Vahinaletra | Stomach-ache     | Leaves          | Decoction   | Oral           | 1                   | 100  | RA 1323     |
| Connaraceae      | Cnestis polyphylla Lam. | Sefana | Diarrhea          | Stem            | Decoction   | Oral           | 1                   | 100  | RKN 511     |
| Crassulaceae     | Kalanchoe proliera (Bowie ex Hook) Raym.-Hamer | Sodifafana | Malaria          | Leaves          | Decoction   | Oral           | 4                   | 31   | RKN 512     |
|                  |                   |            |                  |                |            |                |                    |      |             |
| Cucurbitaceae    | Momordica charantia L. | Margøzy  | Malaria          | Leaves          | Decoction   | Oral           | 2                   | 67   | RZK 3096    |
|                  |                   |            | Stomach-ache     | Leaves          | Decoction   | Oral           | 2                   | 67   |             |
| Cucurbitaceae    | Unidentified | Voatangolehy | Bilharzia        | Leaves          | Heat and press | Oral           | 1                   | 100  |             |
Table 5 Medicinal plants used to treat six most frequent diseases in Ambalabe rural community, Madagascar (Continued)

| Family               | Species                          | Common Name        | Disease          | Part Used       | Preparation | Route | No. | Code |
|----------------------|----------------------------------|--------------------|------------------|-----------------|-------------|-------|-----|------|
| Cunoniaceae          | Weinmannia bojeriana Tul.        | Sokia              | Dysentery        | Bark            | Decoction   | Oral  | 1   | 100  |
|                      |                                  |                    |                  |                 |             |       | RZA | 533  |
| Euphorbiaceae        | Macaranga obovata Boivin ex Ball. | Mankaranana        | Diarrhea         | Bark            | Decoction   | Oral  | 3   | 100  |
|                      | Manihot esculenta Crantz         | Mangahazo          | Diarrhea         | Leaves          | Decoction   | Oral  | 4   | 80   |
| Fabaceae             | Aeschynomene sensitiva Sw.       | Fanombo tintina    | Malaria          | Leaves          | Decoction   | Oral  | 5   | 83   |
|                      | Dalbergia monticola Bosser & R. Rabev. | Hitsika            | Bilharzia        | Wood-heart      | Decoction   | Oral  | 1   | 100  |
|                      | Desmodium ramosissimum G. Don    | Tsilavondrivotra   | Diarrhea         | Leaves, stem    | Heat and    | Oral  | 3   | 60   |
|                      |                                  |                    |                  |                 | press       |       | RKN | 516  |
|                      |                                  | Entada gigas (L.) Fawc. & Rendle | Cough        | Leaves          | Decoction   | Oral  | 1   | 20   |
|                      |                                  |                    |                  |                 |             |       |     |      |
|                      | Senna alata (L.) Roxb.           | 4 épingles         | Bilharzia        | Leaves          | Decoction   | Oral  | 2   | 100  |
|                      | Gentianaceae                    | Exacum quinquenervium Griseb. | Mamoahely       | Malaria         | Decoction   | Oral  | 1   | 100  |
|                      |                                  | Ornichia madagascariensis (Baker) Klack. | Aferotaniala | Whole plant     | Decoction   | Oral  | 1   | 100  |
|                      |                                  | Stcherus flagellans (Bory ex Willd.) Ching | Rangontohitra | Diarrhea         | Leaves      | Decoction | Oral  | 1   | 100  |
|                      | Hypericaceae                     | Harungana madagascariensis Lam. ex Poir. | Harongana      | Diarrhea         | Bark, leaves | Decoction | Oral  | 6   | 27   |
|                      |                                  |                    |                  |                 |             |       | RKN | 1325 |
|                      |                                  | Lam. ex Poir.      |                  |                 |             |       |     |      |
|                      | Lamiaceae                       | Plectranthus perrieri Hinge | Amparimaso      | Diarrhea         | Leaves      | Heat and press | Oral  | 1   | 100  |
|                      | Lygodiaceae                     | Lygodium lanceolatum Desv. | Famlotakanka    | Stomach-ache    | Decoction   | Oral  | 1   | 17   |
|                      | Melastomataceae                 | Clidemia hirta (L.) D. Don | Sompatra        | Diarrhea         | Leaves      | Decoction   | Oral  | 4   | 22   |
|                      |                                  |                    |                  |                 |             |       | RKN | 513  |
|                      |                                  |                    |                  |                 |             |       |     |      |
|                      |                                  |                    |                  |                 |             |       |     |      |
|                      |                                  |                    |                  |                 |             |       |     |      |
|                      |                                  |                    |                  |                 |             |       |     |      |
|                      |                                  |                    |                  |                 |             |       |     |      |
|                      |                                  |                    |                  |                 |             |       |     |      |
|                      |                                  |                    |                  |                 |             |       |     |      |
|                      |                                  |                    |                  |                 |             |       |     |      |
|                      |                                  |                    |                  |                 |             |       |     |      |
| Moraceae             | Artocarpus heterophyllus Lam.    | Ampalibe           | Diarrhea         | Leaves          | Crush       | Oral  | 4   | 100  |
|                      | Ficus polta Vahl                | Mandresy           | Stomach-ache     | Leaves          | Decoction   | Oral  | 1   | 7    |
|                      | Ficus reflexa Thunb.             | Nonoka madinika    | Cough            | Leaves          | Decoction   | Oral  | 1   | 25   |
|                      | Streblus dimpeate (Bureau) C.C. Berg | Manasavelona      | Diarrhea         | Leaves          | Decoction   | Oral  | 1   | 17   |
| Musaceae             | Musa paradisiaca L.              | Akondro            | Diarrhea         | Fruit           | Paste       | Oral  | 3   | 100  |
|                      |                                  |                    |                  |                | Inflorescence, Resin | Decoction | Oral  |     |      |
|                      |                                  |                    |                  |                |             |       |     |      |
|                      | Myristicaceae                   | Ilon-draharaha     | Cough            | Inflorescence   | Heat and press | Oral  | 1   | 33   |
|                      |                                  |                    |                  |                |             |       |     |      |
|                      |                                  |                    |                  |                |             |       |     |      |
| Family          | Species                                      | Common Name          | Disease or Symptom | Part Used            | Preparation       | Route | Quantity | Reference          |
|-----------------|----------------------------------------------|----------------------|--------------------|----------------------|-------------------|-------|----------|---------------------|
| Myrtaceae       | Eucalyptus camaldulensis Dehnh.              | Kininina             | Malaria            | Young leaves         | Decoction         | Oral  | 1        | 50                  |
|                 |                                             |                      | Diarrhea           | Leaves               | Decoction         | Oral  | 1        | 50                  |
|                 | Psidium cattleyanum Sabine                  | Gavo tsinahy         | Diarrhea           | Leaves               | Decoction         | Oral  | 3        | 100 Gentry 11251    |
|                 | Psidium guajava L.                          | Gavo, gavombazaha,   | Diarrhea           | Leaves               | Decoction         | Oral  | 6        | 35 RCS 456          |
|                 |                                              | gavobe               |                    |                      |                   |       |          |                     |
|                 | Syzygium malaccense (L.) Merr. & L.M. Perry | Makoba               | Dysentery          | Bark                 | Decoction         | Oral  | 1        | 6                   |
|                 |                                              |                      |                    |                      |                   |       |          |                     |
| Orchidaceae     | Aerangis hyaloides (Rchb. f.) Schlr.        | Tsiakondroakondro    | Cough              | Leaves               | Heat and press    | Oral  | 1        | 100 AP 7155         |
|                 |                                              |                      |                    |                      |                   |       |          |                     |
| Oxalidaceae     | Oxalis corniculata L.                        | Takasintary          | Cough              | Whole plant          | Decoction         | Oral  | 3        | 100 AP 5034         |
|                 |                                              |                      |                    |                      |                   |       |          |                     |
| Pandanaceae     | Pandanus sp. Parkinson                      | Manasa ala           | Cough              | Leaves               | Decoction         | Oral  | 1        | 100                 |
|                 |                                              |                      |                    |                      |                   |       |          |                     |
| Passifloraceae  | Passiflora edulis Sims                      | Garana madinika      | Diarrhea           | Leaves               | Crush and press   | Oral  | 2        | 50 RCS 456          |
|                 |                                              |                      |                    |                      |                   |       |          |                     |
| Phyllanthaceae  | Phyllanthus nummulariifolius Poir.          | Mandirihariva        | Stomach-ache       | Leaves               | Decoction         | Oral  | 1        | 33 RKN 542          |
|                 |                                              |                      |                    |                      |                   |       |          |                     |
| Piperaceae      | Piper barbonense (Miq.) C. DC.              | Tsimahalatsaka,      | Stomach-ache       | Leaves               | Decoction         | Oral  | 1        | 33 RA 941           |
|                 |                                              | voantsipiferiny      |                    |                      |                   |       |          |                     |
| Pittosporaceae  | Pittosporum ochrosifolium Bojer             | Hazombary, maimbovitsika | Cough              | Leaves               | Decoction         | Oral  | 2        | 50 RA 1322          |
|                 |                                              |                      |                    |                      |                   |       |          |                     |
| Poaceae         | Oryza sativa L.                             | Vary                 | Dysentery          | Seeds                | Cook and filter   | Oral  | 1        | 17                  |
|                 |                                              |                      |                    |                      |                   |       |          |                     |
| Zea mays L.     |                                              | Tsakotkalo           | Stomach-ache       | Stem                 | Decoction         | Oral  | 1        | 100                 |
|                 |                                              |                      |                    |                      |                   |       |          |                     |
| Primulaceae     | Maesa lanceolata Forssk.                    | Radoaka              | Diarrhea           | Leaves               | Decoction         | Oral  | 2        | 100 RKN 500         |
|                 |                                              |                      |                    |                      |                   |       |          |                     |
| Pteridaceae     | Pteris cf. cretica L.                       | Ravimbolo            | Stomach-ache       | Leaves               | Decoction         | Oral  | 1        | 5 RKN 458           |
|                 |                                              |                      |                    |                      |                   |       |          |                     |
| Pteridophyta    | Unidentified                                | Ahitrirmpa           | Cough              | Leaves               | Decoction         | Oral  | 1        | 100                 |
|                 |                                              |                      |                    |                      |                   |       |          |                     |
| Rhamnaceae      | Gouania thilitifolia Lam.                   | Ranovavanaomby       | Cough              | Leaves               | Crush             | Oral  | 1        | 6 RKN 499           |
|                 |                                              |                      |                    |                      |                   |       |          |                     |
| Rosaceae        | Eriobotrya japonica (Thunb.) Lindl.         | Pilbasy             | Cough              | Leaves               | Decoction         | Oral  | 2        | 50 Croat 32156      |
|                 |                                              |                      |                    |                      |                   |       |          |                     |
| Rubus molucanus L. |                                           | Takoaka             | Diarrhea           | Leaves               | Crush, decocation | Oral  | 6        | 60 REH 720          |
|                 |                                              |                      |                    |                      |                   |       |          |                     |
| Rubus rosifolius Sm. |                                        | Voandroy             | Stomach-ache       | Leaves               | Decoction         | Oral  | 1        | 10                  |
|                 |                                              |                      |                    |                      |                   |       |          |                     |
| Rubiaceae       | Breonia decaryana Hormolle                  | Molompanagy         | Bark and leaves    | Bark                 | Decoction         | Oral  | 1        | 20 RZA 158          |
|                 |                                              |                      |                    | and leaves           |                   |       |          |                     |
|                 | Danais terminalis Boivin ex Drake           | Vahinofokorana       | Diarrhea           | Roots                | Decoction         | Oral  | 3        | 100 RKN 680         |
|                 |                                              |                      |                    |                      |                   |       |          |                     |
|                 | Paedia prauniana Baill.                     | Vahivola, vahimantsina | Stomach-ache       | Branch, leaves       | Decoction         | Oral  | 10       | 77 RA 1349          |
|                 |                                              |                      |                    |                      |                   |       |          |                     |
| Rutaceae        | Citrus aurantium L.                          | Voahangy ala         | Stomach-ache       | Young leaves         | Decoction         | Oral  | 1        | 33 AP 5569          |
| Family          | Genus               | Common Name     | Disease   | Part Used | Preparation | Route | Dosage |
|-----------------|---------------------|-----------------|-----------|-----------|-------------|-------|--------|
| Sapindaceae     | Litchi chinensis    | Letisia         | Diarrhea  | Leaves    | Decoction   | Oral  | 8      |
|                 |                     |                 |           |           |             |       | 67     |
|                 |                     |                 | Dysentery | Bark      | Decoction   | Oral  | 2      |
|                 |                     |                 | Stomach-ache | Leaves   | Decoction   | Oral  | 2      |
| Sapindaceae     | Schizolaena         | Kikazana        | Stomach-ache | Leaves   | Decoction   | Oral  | 2      |
|                 |                     |                 |           |           |             |       | 67     |
| Solanaceae      | Capsicum annuum     | Pilopilo        | Stomach-ache | Fruit    | Crush       | Oral  | 1      |
|                 |                     |                 |           |           |             |       | 33     |
|                 | Lycopersicon        | Voatabia        | Diarrhea  | Leaves    | Crush and press | Oral  | 1      |
|                 | esculentum          |                 |           |           |             |       | 100    |
|                 | Mill.               |                 | Stomach-ache | Leaves   | Decoction   | Oral  | 2      |
|                 |                     |                 |           |           |             |       | 40     |
|                 |                     | Radriaka        | Diarrhea  | Leaves    | Decoction   | Oral  | 1      |
|                 |                     |                 |           |           |             |       | 7      |
|                 |                     |                 | Stomach-ache | Leaves   | Decoction   | Oral  | 3      |
|                 |                     |                 |           |           |             |       | 21     |
| Zingiberaceae   | Aframomum angustifolium | Lingoza     | Cough     | Fruit    | Decoction   | Oral  | 1      |
|                 | (Sonn.) K. Schum.   |                 |           |           |             |       | 25     |
|                 | Curcuma longa       | Tamosambo       | Stomach-ache | Tuber    | Decoction   | Oral  | 2      |
|                 | L.                   |                 |           |           |             |       | 40     |
|                 | Zingiber zerumbet   | Sakarivondambo  | Bilharzia | Tuber     | Decoction   | Oral  | 4      |
|                 | (L.) Roscoe ex Sm.  |                 |           |           |             |       | 40     |

Table 5 Medicinal plants used to treat six most frequent diseases in Ambalabe rural community, Madagascar (Continued)
used to treat this disease (*Breonia decaryana*, *Citrus reticulata*, *Dalbergia monticola*, *Senna alata*, *Zingiber zerumbet* and one Cucurbitaceae). Participants did however show a limited knowledge of plants to treat bilharzia.

Concerning the locations of harvest, our study found that only 38.6% of the 83 recorded medicinal plants occurred in Vohibe forest. Most species were collected outside the protected area. Of these 19.3% were cultivated and the remaining were collected in the surroundings of the villages, in house yards, or in some crop fields. Although many of these species might be considered common, some occur only in small forest fragments, and might thus easily be threatened.

**Fidelity level**

Most relevant species for each disease, according to their fidelity, are given in Table 4 with their number of citations. About 31% of them were endemic to Madagascar. One species was relevant for bilharzia, two species for cough, nine species for diarrhea (of which three were endemic) and also two species each for malaria and stomach-ache (one species for each was also endemic). No species was identified as relevant for the dysentery category, because people normally consulted the local doctor for this ailment. The number of citations for the 16 relevant species ranged from two to ten. Only *Paederia thouarsiana* has ten numbers of citations. It is annotated that plant species frequently cited are not always the most relevant for the treatment of one disease. The Table 5 gives more details on the 83 species inventoried as medicinal plants used for the six frequent ailments encountered in the Ambalabe community, with their uses and their fidelity level.

**Discussion**

The use of herbal medicine often reflects a lack of access to modern medicine. Our study focused on medicinal plants used to treat the most frequent diseases encountered in the rural community of Ambalabe and their degree of threats.

The six diseases identified are most common in rural areas in Madagascar, especially those which affect the digestive system [7, 8, 35], and some of them are sometimes considered as major threats in tropical and subtropical countries [36, 37]. However, plant species used are generally diverse, even in the same study area. As well, uses are sometimes different for each plant species cited. Yet, it is very common for one species to be used to treat more than one disease. Informants play an important role on this traditional knowledge richness. This indicates how important the role of an ethnobotanical investigation is on documenting and archiving this cultural inheritance.

Rabearivony et al. [7] conducted a similar study in Ambalabe by documenting the medicinal plants known by men. By considering only the medicinal plants used for the six frequent diseases, the results highlight some similarity and also clear differences between the two studies (Table 6). Species used for diarrhea and stomach-ache treatment were always abundant in the two studies. Yet, no plant species were recorded for dysentery in Rabearivony et al. Concerning the total number of species inventoried, our study found more species used for each disease (except for bilharzia and malaria which are more similar), and only 20 species were common. When compared to other studies conducted in some areas in Madagascar, the number of common species decreased and some literature sources did not give a list of species used for one or two ailments (often bilharzia and dysentery), indicating that each region/locality has its own set of medicinal plants used. Such results highlight the importance of traditional medicine and the diversity of plant species used in the lives of Malagasy people. In this study, the high number of species used reflects the botanical richness of Ambalabe and also the considerable traditional knowledge of the local population, which deserves to be preserved.

**Table 6** Comparison of the present study to other studies conducted in Ambalabe and in Madagascar: species considered are those used for the six frequent diseases

|                  | Present study | Rabearivony et al. [7] | Rakotonandrasana [39] | Razafindraibe [8] | Quansah [19] | Nicolas [38] |
|------------------|---------------|------------------------|------------------------|-------------------|--------------|--------------|
| Total number of species | 83            | 62                     | 22                     | 65                | 7            | 81           |
| Common species used | 20            | 2                      | 12                     | 4                 | 9            |              |
| Number of species per disease | Bilharzia | 6                       | 7                      | 0                 | 0            | 1            |
|                   | Cough         | 14                     | 12                     | 9                 | 18           | 0            | 20           |
|                   | Diarrhea      | 32                     | 20                     | 6                 | 21           | 2            | 41           |
|                   | Dysentery     | 6                      | 0                      | 0                 | 0            | 6            | 3            | 28           |
|                   | Malaria       | 13                     | 14                     | 5                 | 25           | 0            | 17           |
|                   | Stomach-ache  | 30                     | 25                     | 4                 | 12           | 3            | 10           |
| Scientific name                  | Present study | Rabearivony et al. [7] | Rakotonandrasana [39] | Razafindraibe et al. [8] | Quansah [19] | Nicolas [38] | Worldwide     |
|----------------------------------|---------------|------------------------|------------------------|--------------------------|--------------|--------------|---------------|
| Aeschynomene sensitiva Sw.       | Malaria       |                        |                        |                          |              |              |               |
| Aframomum angustifolium (Sonn.) K. Schum. | Cough         |                        |                        |                          |              |              |               |
| Aphloia theiformis (Vahl) Benn.  | Stomach-ache  | Malaria                |                        |                          |              |              |               |
| Artocarpus heterophyllus Lam.    | Diarrhea      |                        |                        |                          |              |              | Diarrhea [43, 44] |
| Canarium L.                     | Diarrhea      |                        |                        |                          |              |              |               |
| Catharanthus roseus (L.) G. Don  | Malaria       | Stomach-ache           | Stomach-ache           |                          |              |              | Malaria [45], diarrhea, dysentery [46], diarrhea [44] |
| Citrus aurantium L.              | Stomach-ache  |                        | Cough                  | Cough, malaria           | Cough        |              | Diarrhea [44] |
| Citrus limon (L.) Burm. f.       | Cough         |                        |                        |                          |              |              | Malaria [47], dysentery [48] |
| Clidemia hirta (L.) D. Don       | Diarrhea, malaria, stomach-ache |                        |                        |                          |              |              |               |
| Curcuma longa L.                 | Stomach-ache  | Malaria                |                        |                          |              |              | Cough [49]    |
| Cyanthillium cinereum (L.) H. Rob.| Stomach-ache  |                        |                        |                          |              |              |               |
| Danais terminalis Boivin ex Drake| Diarrhea      |                        |                        |                          |              |              |               |
| Desmodium ramosissimum G. Don    | Cough, diarrhea |                        |                        |                          |              |              |               |
| Elephantopus scaber L.           | Diarrhea, stomach-ache |                        |                        |                          |              |              | Diarrhea, dysentery [43] |
| Entada gigas (L.) Fawc. & Rendle | Diarrhea      |                        |                        |                          |              |              |               |
| Eriobotrya japonica (Thunb.) Lindl. | Cough        |                        |                        |                          |              |              | Cough [50]    |
| Exacum quinquenervium Griseb.    | Diarrhea      |                        |                        |                          |              |              |               |
| Ficus polita Vahl                | Stomach-ache  |                        |                        |                          |              |              | Malaria [47, 51] |
| Harungana madagascariensis Lam. ex Poir. | Diarrhea  |                        |                        |                          |              |              |               |
| Kalanchoe proliferata (Bowie ex Hook.) Raym. Harnet | Cough, malaria |                        |                        |                          |              |              | Cough         |
| Lantana camara L.                | Diarrhea, stomach-ache |                        |                        |                          |              |              | Malaria [43], cough [52], malaria [51] |
| Litchi chinensis Sonn.           | Diarrhea, dysentery, stomach-ache |                        |                        |                          |              |              |               |
| Lygodium lanceolatum Desv.       | Stomach-ache  |                        |                        |                          |              |              | Stomach-ache  |
Regarding the uses of plant species recorded, those of the common species reported from the different literature cited in Table 6, including the 16 most relevant species identified in this study, were compared to other uses found in some worldwide literature consulted (Table 7). The table shows that uses are most common around the world for some cosmopolitan species like Artocarpus heterophyllus, Elephantopus scaber, Musa paradisiaca and Psidium guajava. Common use of these plants might indicate their efficacy for treatment. However, our study reported the unique use of eight of the most relevant plant species, of which four (50 %) were endemic to Madagascar. *Aeschynomene sensitiva* (not endemic) was only used for malaria, *Canarium* sp. (endemic), *Danais terminalis* (endemic), *Macaranga obovata* (endemic), *Maesa lanceolata* (naturalized) and *Raphia farinifera*

### Table 7 Comparison of the uses of all common species inventoried in Table 6 to worldwide uses (Continued)

| Species                                      | Use(s)                                      | Use(s)                                      | Use(s)                                      |
|----------------------------------------------|----------------------------------------------|----------------------------------------------|----------------------------------------------|
| Macaranga obovata Boivin ex Baill.           | Diarrhea                                     |                                              |                                              |
| Maesa lanceolata Forsk.                      | Diarrhea                                     |                                              |                                              |
| Manihot esculenta Crantz                     | Diarrhea                                     |                                              |                                              |
| Mauloulchitrus humboldii (H. Perrier) Capuron | Cough, Cough                                 | Cough, Cough, Malaria                       |                                              |
| Mollugo nudicaulis Lam.                      | Malaria, stomach-ache                        | Cough, diarrhea, malaria                     |                                              |
| Musa paradisiaca L.                          | Diarrhea, dysentery                          | Diarrhea                                    |                                              |
| Oxalis corniculata L.                        | Cough                                        |                                              |                                              |
| Pandenia thouariiana Baill.                  | Stomach-ache                                 |                                              |                                              |
| Petchia erythrocarpa (Vatke) Leeuwenb.       | Malaria                                      |                                              |                                              |
| Psidium cattleyanum Sabine                   | Diarrhea                                     | Diarrhea                                    |                                              |
| Psidium guajava L.                           | Diarrhea, dysentery                          | Diarrhea, dysentery, malaria                 |                                              |
| Raphia farinifera (Gaertn.) Hyl.             | Diarrhea                                     |                                              |                                              |
| Ravenala madagascariensis Sonn.              | Stomach-ache                                 | Cough, stomach-ache                         |                                              |
| Senecia alata (L) Roxb.                      | Bilharzia                                    |                                              |                                              |
| Sorindeia madagascariensis DC.               | Diarrhea, stomach-ache                       | Stomach-ache                                |                                              |
| Toddalia asiatica (L) Lam.                   | Malaria, stomach-ache                        |                                              |                                              |
| Zea mays L.                                  | Stomach-ache                                 |                                              | Cough                                        |
will be needed to better understand the importance of traditional medicine. Besides, because 83 species were used to treat six most frequent diseases, their conservation should be considered as important to ensure sustainable future use, especially due to the fact that most of them were collected in the surroundings of the villages and in non-protected areas. Sustainable management techniques should be considered, especially for Malagasy endangered species.

Additional file

Additional file 1: Guide d’entretien utilisé. (PDF 15 kb)

Competing interests
The authors declare that they have no competing interests.

Authors’ contributions
All authors participated in the study design. NRH carried out the study, analyzed the data and drafted the manuscript. All authors read and approved the manuscript.

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References
1. Selu T. Ethnobotanical and ethnopharmacological studies on medicinal plants of Chifra district, Afar region, North Eastern Ethiopia, PhD Thesis. Addis Ababa University: School of Graduate Studies; 2004.
2. World Health Organisation. Health of indigenous peoples. Geneva, Switzerland: Factsheets N° 326; 2007. http://www.who.int/mediacentre/factsheets/fs326/en/. Accessed 30 April 2015.
3. Bussmann RW, Sharon D. Traditional medicine plant use in Northern Peru: tracking two thousand years of healing culture. J Ethnobiol Ethnomed. 2006;2:47.
4. Bussmann RW, Glenn A. Peruvian medicinal plants for the treatment of liver and gallbladder ailments. Amoldoa. 2010;17(2):243–53.
5. Bussmann RW, Glenn A. Plants used for the treatment of gastro-intestinal ailments in Northern Peruvian ethnomedicine. Amoldoa. 2010;17(2):255–70.
6. Randrianarivelojosia M, Rasidimanana VT, Rabarison H, Cheplogoi PK, Ratsimbason M, Mulholland DA, et al. Plants traditionally prescribed to treat tzoa (malaria) in the eastern region of Madagascar. Malar J. 2003;2:225.
7. Rabearivony T, Kuhlman AR, Razafiarison V, Raharimala F, Rakotoarivony F, Randriarivony T, et al. Ethnobotanical study of the medicinal plants known by men in Ambalabe, Madagascar. Ethnobotany Research & Applications. 2015;14:123–38.
8. Razafindralaibe M, Kuhlman AR, Rabarison H, Rakotoarison V, Rajeriarison C, Rakotoarivelo N, et al. Medicinal plants used by women from Agonalaza littoral forest (Southeastern Madagascar). J Ethnobiol Ethnomed. 2013;9:73.
9. Conservation International, World Wildlife Fund. Assessing the impacts of climate change on Madagascar’s biodiversity and livelihoods - A workshop report. Antananarivo: MEEFT; 2008.
56. Shanmugam S, Annadurai M, Rajendran K. Ethnomedicinal plants used to cure diarrhoea and dysentery in Pachalur hills of Dindigul district in Tamil Nadu, Southern India. Journal of Applied Pharmaceutical Science. 2011;1(8):94–7.

57. Tangjitman K, Wongsawad C, Kamwong K, Sukkho T, Trisonthi C. Ethnomedicinal plants used for digestive system disorders by the Karen of northern Thailand. J Ethnobiol Ethnomed. 2015;11:27.