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Rimbo Larangan photo by Riko Coubout

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Book:

Rai MK, Carpinella C. 2006. Naturally Occurring Bioactive Compounds. Elsevier, Amsterdam.

Chapter in book:

Webb CO, Cannon CH, Davies SJ. 2008. Ecological organization, biogeography, and the phylogenetic structure of rainforest tree communities. In: Carson W, Schnitzer S (eds) Tropical Forest Community Ecology. Wiley-Blackwell, New York.

Abstract:

Assaeed AM. 2007. Seed production and dispersal of *Rhazya stricta*. 50th Annual Symposium of the International Association for Vegetation Science, Swansea, UK, 23-27 July 2007.

Proceeding:

Alikodra HS. 2000. Biodiversity for development of local autonomous government. In: Setyawan AD, Sutarno (eds.) Toward Mount Lawu National Park; Proceeding of National Seminary and Workshop on Biodiversity Conservation to Protect and Save Germplasm in Java Island. Universitas Sebelas Maret, Surakarta, 17-20 July 2000. [Indonesian]

Thesis, Dissertation:

Sugiyarto. 2004. Soil Macro-invertebrates Diversity and Inter-Cropping Plants Productivity in Agroforestry System based on Sengon. [Dissertation]. Universitas Brawijaya, Malang. [Indonesian]

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Ethnobotany of traditional rituals in the Karangwangi Village, Cianjur District, West Java, Indonesia

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Abstract. *Erawan TS, Alillah AN, Iskandar J. 2018. Ethnobotany of ritual plants in Karangwangi Village, Cianjur District, West Java, Indonesia. Asian J Ethnobiol 1: 53-60.* According to Sundanese tradition, each Sundanese village community practice some distinctive traditional rituals in which diverse plants grown in different local ecosystems are used. The objectives of this study were to document the traditional rituals performed by the people of Karangwangi Village, Cianjur, West Java, Indonesia and various plants used in these traditional rituals, by employing qualitative and quantitative ethnobotanical approaches. To collect primary data, techniques namely observations and deep interviews were applied. The results of the study showed that 6 kinds of traditional rituals have been practiced by the village people of Karangwangi. These traditional rituals are locally named as **srokalan** (the traditional ritual of naming the baby), **nikahan** (the traditional ritual of wedding), **nujuh bulanan** (the traditional ritual associated with seventh month of pregnancy), **nyepitan** (the traditional ritual of circumcision), **upacara pare** (the traditional ritual of planting rice) and **upacara nelayan** (traditional ritual of fishermen before going to sea). As many as 26 species representing 17 families of plants are used in these rituals. The plants used in traditional rituals were harvested mainly from the homegarden systems and most of these species also commonly used as spices. As the plants used in the traditional rituals have been predominantly cultivated in the homegardens, these plants are indirectly conserved by the village people.

Keywords: Cianjur, Karangwangi Village, traditional ceremonies, ritual plants

INTRODUCTION

Humans always have interrelationships with the local environment, in their daily life (Marten 2001; Iskandar 2017; 2018). In the relationships between humans and local environment, there is flow of energy, matter, and information. The main source of energy in nature is the sun and plants, as producers, convert solar energy through the process of photosynthesis, producing oxygen and carbohydrate. Furthermore, oxygen is used by humans for daily human life to breathe, while energy in the form of carbohydrate crops, including rice, corn, cassava, and sweet potato, can be consumed for human food. In addition, humans obtain information from information, in terms of flora, fauna, climate, crops, pests and so on from the ecosystem that can be used as various human knowledge to be used for utilizing and managing the ecosystem (Iskandar 2017). Although humans are part of the ecosystem, human-nature interaction is considered as an interaction between the human social system and the rest of the ecosystem. The social system is everything about people, their culture and social organization that shapes their behavior. People make sense of the complexity that surrounds them or their local environment by carrying a lot of information. People and society use the world around them to interpret information and formulate actions to adapt to their environment. As a result, the local people in their prolonged relationships with the environment may accumulate various information which is called local knowledge, indigenous knowledge, traditional ecological knowledge or local ecological knowledge. Its important characteristics are it is local, transmitted orally, based on personal experiences of local people’s interactions with their environment for a long time and its trial and error based on empirical results instead of theory (Ellen and Harris 2002; Iskandar 2012).

Initially, the local village people utilized their local natural resources and their environment mainly based on the local knowledge and worldview, cosmos or belief which are embedded in their culture (Toledo 2002; Iskandar 2018). Therefore, the human culture can be understood as the human knowledge containing various devices of knowledge models that effectively used by the human to interpret and to understand his or her environment and as guidelines for appropriate behavior in accordance with the environment(Supernal 2005; Ahimsa-Putra 2012).

Indonesia has high biodiversity and ethnic diversity with various distinctive cultures (Widjaja et al. 2014). For example, more than 30 ethnic groups with at least 655 local languages or mother languages have been registered (Sastrapradja 2010; Iskandar 2016). Every ethnic group of Indonesia has a specific culture based on its continuous interaction with the environment.

The Sundanese people who reside in West Java and Banten have specific culture and various customs (*adat)* in their daily life. Initially in the past, rural people of West Java utilized and managed their environment based on the knowledge and beliefs or cosmos (Berkes 2008; Iskandar 2018). As a result, rural people have properly managed their environment and utilized rural resource with sustainable system. According to ecological or environmental history, the village people of Sundanese had custom (**adat**) beliefs on natural spirits, such as place spirits and gods and goddesses (*dewa* and *dewi*). For example, their rice farming system is based on the local knowledge and cosmos or beliefs. The rice had a goddess called *Nyi Pohaci* (called *Dewi Sri* in Javanese). In addition, areas such as water springs, forests with springs, and the water first entering the rice field (*hulu wotan*) were perceived as sacred places (Wessing 1978; Mustapa 1996) and were traditionally conserved. In the past, before the modernization through the green revolution, the rice farming system of Sundanese was based on the ecological local knowledge deeply embedded in their culture. Almost every stage of the rice farming, such as land preparations, planting, and harvesting was accompanied by traditional rituals in the form of *hajatan* or *selametan* (also spelled as *slametan*) to respect the rice goddess and environment. A *hajat*, in its most basic meaning, is a communal meal. The world *slametan* is an alternate term for hajat derived from the Arabic word *salamat* or *salam*. The purpose of *slametan* is to *nyalametkeun* something. That is, to bring it into the condition of *slamet* (well-being) (Wessing 1978). Besides rice farming, such traditional rituals were also practiced during other occasions wedding, pregnancy childbirth, circumcision, funeral, etc. (Prawirasuganda 1964; Mustapa 1996). Various materials including some plants, such as sirih (*Piper betle* L.), pinang (*Areca catechu* L.), kunir or koneng (*Curcuma domestica* Val.) and rice (*Oryza sativa* L.) which have symbolic functions have been predominantly used in the traditional rituals of Sundanese people (Prawirasuganda 1964; Iskandar and Iskandar 2017). However, presently these traditional rituals involving use of local plants are very rarely performed by the Sundanese people which may eventually result in their complete disappearance.

The present study was therefore undertaken in the village of Karangwangi, Cianjur, West Java with the aim of documenting the local traditional rituals, in general, and documenting the use of local plants involved in such rituals, in particular.

MATERIALS AND METHODS

Area study

Karangawangi is a village located in Cidaun Sub-district, Cianjur District, West Java Province, Indonesia. Geographically, the Karangwangi village lies between 7° 25'- 30'LS 7° and 107° 23'-107° 25 'E (Figure 1). The distance from Karangwangi village to Cidaun Subdistrict, Cianjur District, and Kota Bandung is 16 km, 156 km, and 216 km, respectively.

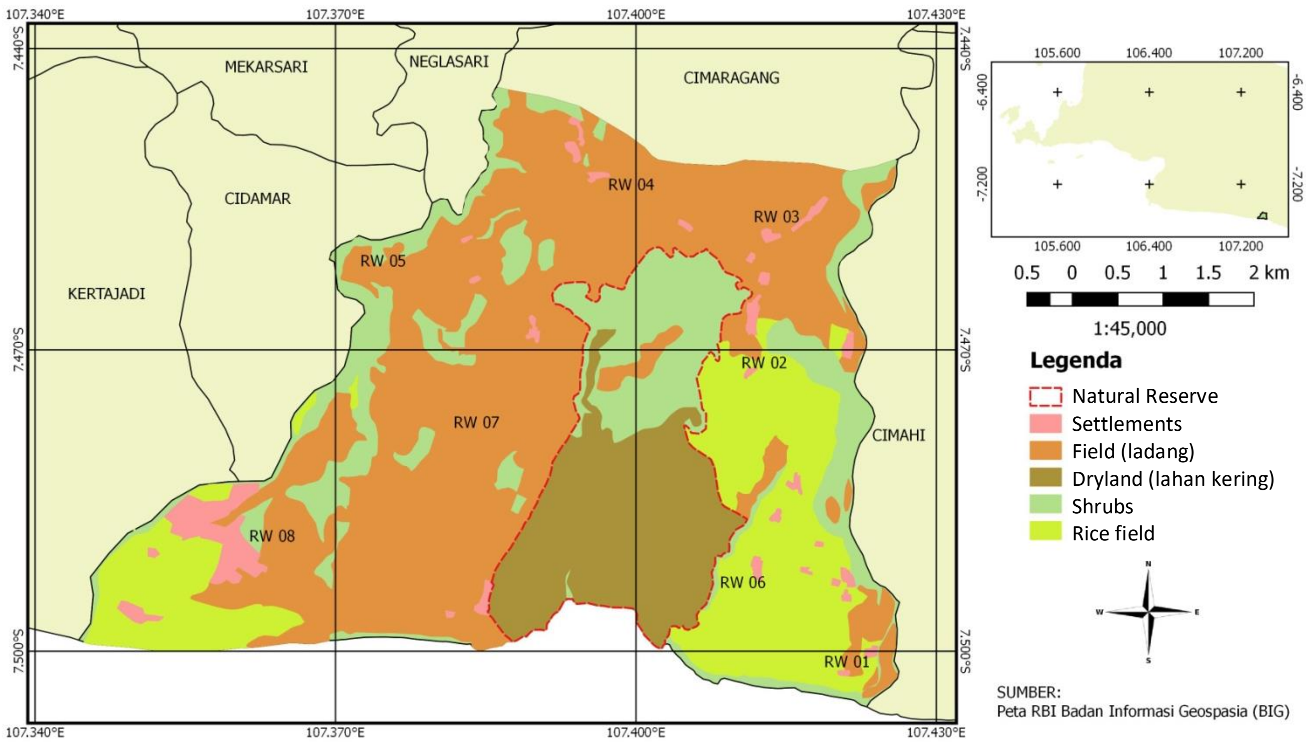

Figure 1. Map of the study area in Karangwangi Village, Cidaun Sub-district, Cianjur District, West Java Province, Indonesia

The road between Karangwangi village and Cianjur was improved and widened (Figure 2). As a result, the urban people who want to visit the tourist area of Rancabayawak can pass this village using motor vehicles.

The Karangwangi village has a total area of about 23.52 km^2. The land use of Karangwangi village consists of settlements, agricultural lands, and forests. The settlement area is mainly used as place for constructing houses by village people. The houses are divided into two types, the traditional houses made of bamboo and wood, and modern houses made of more permanent cement buildings (Figure 3).

The agricultural land consists of both dryland agricultural systems and wetland agricultural systems. The dry land agricultural system involves several agro-ecosystem types, namely homegardens, gardens, mixed-gardens, and swidden agriculture (*huma*) (cf. Iskandar and Iskandar 2011; Iskandar et al. 2016). The wetland agricultural system is composed of the rain-fed rice fields, irrigated rice fields, and tidal rice fields. The Karangwangi village is located directly adjacent to the forest. This forest was formally established as a nature conservation site, Nature Conservation of Jayanti (BKSDA 2012; Himakova 2013). It has a total area of 75.00 hectares that is established by the decree of SK Mentan No.516/Kpts/Um/10/1973, Tanggal 16 Oktober 1973.

The estimated population of Karangwangi village In 2014 was 5,672, with the main occupation of the people recorded as farmers and farm laborers. In addition, a small number of people are traders, carpenters, and fishermen. The various livestock recorded in the village consist of 2,767 non-race chicken (*ayam bukan ras*), 245 ducks, 364 cows and 35 buffaloes (Statistic of Karangwangi village 2014).

Methods

Method used in this study was qualitative with ethnobotanical approach (cf. Martin 1995; Cotton 1996; Balic and Cox 1999; Cunningham 2001; Iskandar 2012). To collect the primary data, special techniques namely observations and deep interview were applied. The field observation method was used to record the general conditions of the settlement areas, homegardens, gardens, mixed-gardens, rice fields, and forest area. In addition, it was also used to observe various plants grown in the agricultural lands, particularly in the homegardens, that are involved in traditional rituals and the people who are conducting traditional rituals in the Karangwangi village.

The deep interviews were carried out with competent informants purposively selected by the snowball technique by firstly asking main informants. The informants involved village staff, informal leaders, elderly men and women farmers, and shamans. These deep interviews or semi-structured interviews with informants were undertaken in their houses using a special interview guide and information on names of various traditional rituals, details of the traditional rituals, various plants used in them, and harvesting of these plants were collected. In addition, all plants that have been commonly used in the traditional rituals were collected with the assistance of informants, from the local agricultural systems, particularly the homegardens.

The qualitative data was analyzed by cross-checking, summarizing, synthesizing, and combination of descriptive and evaluative analysis, while the botanical identification of commonly used plants was done by referring to local flora(Backer and Bakhuizen 1968; Heyne 1987; Balqooy 1999).

Figure 2. Newly improved village road established in the Karangwangi village (*left*)
Figure 3. Two types of houses of the Karangwangi village, the traditional house and the modern permanent cement building house (*right*)

RESULTS AND DISCUSSION

On the basis of the interviews, information about 6 traditional rituals commonly practiced by the people of Karangwangi village has been recorded. The details of these rituals in the order of their appearance in the family life, and the plants used in them are described below:

The traditional ritual of 'Nikahan'

The wedding ceremony that has been commonly undertaken by the people of Karangwangi village is recognized as a dominant practice, particularly in the past, by the Sundanese family, such as ethnic Sunda of West Java. The traditional ritual of wedding (*nikahan* or *resepsi pernikahan*) in Karangwangi village, Cianjur is mainly intended as a form of expression of gratitude of the bride's family.. According to Suciati (2012), the marriage custom is traditionally practiced by the community to organize the marriage, while the marriage ritual is an activity customarily undertaken to prepare, implement, and consolidate the marriage. Each stage of the wedding ritual contains the element of purpose, place, time, tools, implementer, and implementation of the ritual.

The marriage has been believed to have some purposes , mainly: (i) concern on the value of people's life; (ii)it is the sacred duty of human to have a good descendants useful to the community; (iii) to carry out the command of God and the Sunnah of his prophet; and (iv) bequeath of tradition science and wealth to the heirs.

It has been recorded that at least 6 six species of plants are commonly used for performing the traditional ritual of wedding. They are bamboo (*Bambusa vulgaris* Schhrad*),* paddy (*Oryza sativa* L.), kunyit (*Curcuma domestica* Val.), bunga mawar (*Rosa hibrida* Hort), bunga melati (*Jasminum sambac*(L.) W.Art), and dan bunga sedap malam (*Epiphyllum oxipetalum* (DC) Haw). In the wedding procession, an event is recognized that is called 'stepping on an egg' (***nincak endog)***. In this event, an egg placed under two bamboo blades is trampled and broken by the groom. Then water is poured, from a pitcher, by the bride on the groom's foot that has stepped on the egg by. In addition, another event is called ritual of **nyawer** in which money and flowers are put in a silver bowl, then the flowers and coins are thrown sown by the bride on the invited guests. Besides, hulled rice mixed used with coins are also commonly used for the ritual of **saweran.** Various objects used in the ceremony have symbolic meaning. Rice (*Oryza sativa* L) has a symbolic meaning for happiness, so the bride and groom are expected to be happy and prosperous in their lives. Koneng temen or kunir (*Curcuma domestica* Val) symbolizes yellow or gold or a symbol of glory. So, it is expected that the new family will have enough food and clothing, and have more money to buy gold jewelry, so that they will become happiness family. Various kinds of flowers contain symbolic meaning of fragrance and are beautiful in view. Then the new family is expected to have good behavior such as being able to help other families who need help, so that the new family has a 'good name family', like a fragrance flower. While coins or small money symbolize 'rizki' or property. Hopefully, the new family can later have enough money for his life. So all objects thrown by brides and picked up by guests are symbolic as advice for brides or guests to live in family, can have happiness (symbolic of rice), happiness (symbolized by koneng temen), fragrance of names (symbolized by flowers) and have enough property (symbolized by money) (Prawirasuganda 1964). The money and hulled rice have important symbolic functions, such as the new couple in their life will get wealth and happiness. While kunir or koneng temen (*Curcuma domestica* Val) is tended to looking for treasures must be honest and patient (in Sundanese **temen well**) (Prawirasuganda 1964). Indeed, the persons who have got the money sown by the bride are believed to be lucky.

Ritual of step on the chicken egg (*nicak endog*) is carried out by firstly the bride walking toward the special ceremony place. Then the bride burned a bundle of seven sticks of Arenga palm (*harupat*) in the flame of the candle held by the hand of the groom, and after extinguishing the stick of Arenga palm removed. Furthermore, the groom's right foot stepped on the chicken egg resulted the egg broke. Then the foot of the groom who has been used to step on the egg is washed on the stone by the bride using the water put it in a container made of clay (*kendi).* Then the *kendi* is slammed into the ground until it broke. Symbolic meaning of the ceremony, Arenga palm sticks have hard but easily broken properties. It has a symbolic meaning for the bride that they should not be irritable, the bad nature must be discarded (symbolized by throwaway Arenga palm stick). The candle flame gives meaning to the advice of the bridge that if they live in 'darkness' (got problems) they must counsel, so that they become peaceful (symbolized by the flame of giving light to darkness). Chicken egg has symbolic meaning of life seeds, starting of work to be done, while breaking eggs and washing feet with water has a symbolic meaning if they have bad faith to be solved by discussions.

The events of 'the stepping on an egg' (***Nincak endog)*** and sowing money, rice, and flowers (***Nyawer***) are actually prayers and advice to the new couple in symbolic forms. The stepping on an egg is intended the new couple carrying out his life together, can live harmoniously, work together, understand each other, be avoided from disturbances that disturb family relationships, and can able to cope various obstacles of life. Similarly, the procession of **sawer** is intended to express gratitude of the bridge for the implementation of the wedding program. In addition, it has a symbolic function of prayer or hopes for the marriage to give blessing and is always provided sustenance.

Several plant species are y used for performing the ritual of **saweran,** including paddy (*Oryza sativa* L.), koneng (*Curcuma domestica* Val.), bunga mawar (*Rosa hibrida* Hort), bunga melati (*Jasminum sambac* (L) W.Art) and bunga sedap malam (*Epiphyllum oxipetalum* (DC) Haw.

The traditional ritual of 'Nujuh Bulanan'

The traditional ritual of '**Nujuh Bulanan'** is a ritual that has been performed during seventh month of pregnancy. This ritual is performed in the form of a prayer by the family. This event begins with determining the time, such as the 7th, the 17th or the 27th. Then the various ceremonial needs are provided, in the form of various plants, usually all seven types, such as seven kinds of flowers. Before the ceremony is carried out, the water is stored in a large basin, with seven kinds of flowers inserted. Besides that, *rujak* is also provided in a large plate. After people gather, then prayers are begun. After praying, the water of a large basin is taken with the dipper poured on a woman's hair of seven months pregnant by her mother and father, as well as her brothers. At that time, everyone who wants to be able to get 'rujak' pretends to buy 'rujak' by using money made from broken tiles. Cereal plant products, including kacang merah (*Phaseolus vulgaris* L), kacang hijau (*Phaseolus radiatus* L), jagung (*Zea mays* L) and padi (*Oryza sativa* L) or tuberous plants, including taro (*Colocasia esculenta*). Tuberous plants (**beubeutian***)* have been predominantly used for the performing the ritual of **Nujuh Bulanan**. The plant seeds used in the ritual of **Nujuh Bulanan** have been traditionally planted by pregnant women. They hope that the baby in their womb will be healthy, strong, and later born with no problems. in the proses giving money do not get any problem. Bawang putih (*Allium sativum* L) used in this ritual has symbolic function and is intended to hope that the baby will be kept away from the interference of supernatural powers. In addition, several plants namely fruits of anggur (*Vitis vinifera* L), papaya (*Carica papaya* L), and panglai or banglai (*Zingiber purpureum* Bl) which are mixed in to a fruit preparation called **rujak** is prepared by the expecting mother. The **rujak** is served to the visitors. It has been traditionally perceived by the people that, if the **rujak** is tasted spicy, the baby to be born is predicted to be a male. Conversely, if the rujak is not spicy, the baby to be born is predicted to be a female.

The traditional ritual of 'Asrokalan'

The traditional ritual of **Asrokalan**, **Asrokal** or **Srokalan** was initially undertaken to commemorate the birth of Prophet Muhammad or **Muludan**. It has been known some traditional rituals to glorify the Islamic months (**memuliakan bulan**), such as **Muludan** (**Rabi'ul-awal**) and **Rajaban** (isra and mi'raj of Prophet Muhammad) are commonly undertaken by Sundanese people (Prawirasuganda 1964). Muludan has become a tradition of Muslim Sundanese people to commemorate the birthday of Prophet Muhammad which is usually held on the 12th of Rabiul Awal of Muslim calendar. Mulud month is considered one of the holy months. On the anniversary of the Prophet's birthday, there are some people doing fasting circumcision because it is considered good in the month, making pilgrimages to the tomb, performing Islamic art, and religious lectures. In addition, the term 'Mululdan' has been applied for procession of the traditional ritual of naming a newborn baby, called **Asrokan**. Since the traditional ritual of **Asrokan** has been differently perceived by the village people, only some people conduct this ritual. Two plant species namely kelapa gading/kelapa hijau (*Cocos nucifera* L) and pisang kapas (*Musa paradisiaca* L) have been predominantly used for performing the traditional ritual of **Asrokan**. The fruit of coconut is holed on the top and put on a banana leaf that is folded in the shape of a cone (**dicongcotan**). In addition, the fruit of **pisang kapas** is mixed with sugar palm and used as offering in the ritual.

The use of the plants of coconut and banana in the performing of this traditional ritual is interpreted as the pride of the baby name that has been given, as is traditionally called **"*nyimas kalaras rasa*". Giving baby names depends on the wishes of each family, such as Sundanese special names, names of Islamic leaders, Sanskrit, and Dutch or European names.** In general, giving the name to a baby by the parent that is considered to be good and will be good for the child's life in the future. The ceremony for naming the baby was carried out with a ceremony attended by relatives and others. t is wished that the name of the baby can provide positive energy, give good character, easy fortune treasure, and avoid jealousy and envy. In addition, the procession of this ritual as a form of prayer given by the parent, brothers, and sisters, neighbor to the baby given name.

The traditional ritual of 'Nyepitan' or 'Bubuka'

The traditional ritual of **Nyepitan** or **Khitanan** is usually undertaken by a family after a boy has been circumcised. It is intended as a form of gratitude of the father that his son has been completely circumcised. Some plants namely betel leaf/daun sirih (*Piper betle* L), fruit of areca nut/buah pinang (*Areca catechu* L), tobacco leaf/daun tembakau (*Nicotiana tabacum* L), palm leaf/daun aren (*Arenga pinnata* (Wurmb) Merr), jinger tuber/ rimpang jahe (*Zingiber officinale* Roxb), turmeric tuber/rimpang kunyit (*Curcuma domestica* Val), and candle fruit/buah kemiri (*Aleurites moluccana* (L) Willd) are commonly used for performing this traditional ritual of circumcision**.**

The meaning of the use of plants is a form of prayer or wish to God by a boy who has been circumcised is always in the protection of God. In addition, the circumcised boy has become piety, a real Muslim, who can distinguish prohibition (**haram**) and obligations of religion (**halal**). He has not become a bad child, does not have purpose in life, and does not have spirit of life.

The traditional ritual of 'Upacara Nelayan'

The village of Karangawngi is an area that is bordered by the Indonesian sea to the south. Therefore, some people of the Karangwangi have been recognized as fishermen. Like other fishermen in West Java, the fishermen of Karangwangi have still maintained the traditional ritual that is called **Upacara Nelayan**. This annual ritual is commonly carried by the fishermen in Jayanti beach. The **Upacara Nelayan** is led by a fisherman leader and a witch man (**dukun**). The ritual is attended by the community of fishermen, non-fishermen and a village leader. The traditional ritual of **Upacara Nelayan** is intended to wish the God blessing, protection and lucky for the fishermen to catch fishes in the sea. The ritual is usually carried out in July or August that the weather at that time considered a good and appropriate for catching fishes in the sea.

Several plants namely fruit of a citrus/buah jeruk (*Citrus sinensis* (L) Osbeck), fruit of an apple/buah apel (*Pyrus malus* L), and the coffee/buah kopi (*Coffea robusta*) mixed with milk, fruit of a banana/pisang kapas (*Musa paradisiaca* L), fruit of green a coconut/kelapa hijau (*Cocos nucifera* L*)*, and a banana leaf are commonly used in the traditional ritual of **Upacara Nelayan**. Those fruits are put on a filter tool made of bamboo (ayakan) or winnow that is formed a cone.

All offering is considered as respect or a symbol for the prayer of the fishermen wishing when they are fishing given smoothness, getting a lot of fish, the weaves are not too big, and given salvation. On the basis of the **Dukun** belief, the Jayanti beach is inhabited by a princess that is named as Jayanti Princess (**Puteri Jayanti**). She is perceived as the ruler and control of the South Coast. Therefore, the traditional ritual of **Upacara Nelayan** is considered as ask permission to **Puteri Jayanti.** Since the fishermen fishing has not offered the ritual or getting permission from the **Puteri Jayanti**, she may get angry in the form of a big wave, bad weather, a loss of fish catch, and even occurring of disaster and death of fishermen. Consequently, the fishermen believe that to get the safety of the fishermen, the ritual of **Upacara Nelayan** is considered very important and must be undertaken by the fishermen community. This tradition of the local community of the Karangwangi village of Cianjur is quite the same as mentioned by ethnoecology scholars that initially the local people have managed their local natural sources and their environment based on the traditional ecological knowledge and beliefs, and can assist to conserve the natural resources of village ecosystem (Toledo 2002; Carlson and Maffi 2004; Berkes 2008).

The traditional ritual of 'Upacara Pare'

The ritual of rice (**upacara pare**) is one of the traditional rituals that has been maintained by the local people of Karangwangi village, Cianjur. This ritual is commonly performed before planting rice in the swidden field and wet-rice field. The traditional ritual of **Upacara pare** usually undertaken twice every year, because traditionally rice is planted two times in a year.

Several plant species, namely the fruit of kelapa hijau (*Cocos nucifera* L.), leaves of kemangi (*Ocimum basilicum* L.), and tobacco/tembakau (*Nicotiana tabacum* L.) are commonly used to perform the **Upacara pare**. These plants are predominantly harvested from the homegarden systems. Therefore, various annual and perennial plants are traditionally planted in the homegarden system. As a result these plants may provide socio-economic and cultural functions for the village people, including for performing the traditional rituals. Thus, the traditional rituals are considered to be playing an important role in conserving various plants. This is because as long as the plants are needed for performing the traditional rituals, these plants are maintained by village people by planting them in the homegardens.

Plants used for performing rituals

The traditional rituals are considered mainly as an expression of gratitude, and the processions are performed as prayer or wish to **Sang Pencipta**. According to informants, each prayer or wish of the procession associated with the traditional ritual is completed by offerings as indications of honor to **Sang Pencipta.** On the basis of the field research, 26 species representing 17 families of plants have been found to be commonly used for performing the 6 main traditional rituals of the Karangwangi people, Cianjur (Table 1; Figure 2). Lifeform analysis of the plants used in the traditional rituals has indicated that 44 % of them are herbs, 36 % are trees, 16 % shrubs, and 4 % bushes. In terms of the parts used, 6 main categories can be identified, namely root, stem, leaf, flower, seed, and fruit. Fruit, seed, and flower are the predominantly used parts for performing the traditional rituals by the village people of Karangwangi (Table 2).

Fruits of pinang (*Areca catechu* L), aren (*Arenga pinnata* (Wurmb) Merr), papaya (*Carica papaya* L), kelapa (*Cocos nucifera* L), and pisang (*Musa paradisiaca* L) are commonly used for the traditional rituals. These plants are predominantly harvested from the homegardens. The homegarden systems of Karangwangi people are commonly planted with annual and perennial plants which are commonly used for rituals, and also as sources of additional staple foods, fruits, spices, and vegetables (Figure 4).

On the basis of the present survey of plants, it can be argued that a high diversity of plants are commonly used by the village people of Karangwangi, Cianjur for performing their traditional rituals. However, when compared to that of Baduy community, the diversity of plants used by Karangwangi appears to be less. Baduy community use about 50 species representing 28 families of plants for performing 9 stages of their swidden farming activities(Iskandar and Iskandar 2017). This is because the Baduy people have still strongly maintained their traditional culture compared to that of the Karangwangi people. For example, the swidden farming systems of the Baduy community are still strongly based on the local knowledge and beliefs and some inputs of the farming systems, such as synthetic pesticides, inorganic fertilizers and modern rice varieties are traditionally prohibited. Indeed, almost every stage of the swidden farming, including land preparations, planting, weeding, and harvesting rice, are associated with traditional rituals.

Table 2. Parts of plants have been commonly used for performing rituals of people of Karangwangi village, Cianjur, West Java, Indonesia

Parts of plants used in the traditional rituals	Number of species	Percentage of the total
Root	2	7.69
Stem	1	3.84
Leaf	3	11.53
Flower	4	15.38
Seed	7	26.92
Fruit	9	34.61
Total	26	100.00

Table 1. Plants commonly used for performing the traditional rituals by the people of Karangwangi, Cianjur, West Java, Indonesia

Scientific name	**Family**	**Local name**	**Part of plant used**	**Ritual**
Aleurites moluccana (L) Willd	Euphorbiaceae	Muncang/kemiri	Seed	Ritual of seventh month of pregnancy (**upacara tujuh bulanan**), circumcision (**sunatan/khitanan or nyepitan**)
Alium sativum L	Liliaceae	Bawang bodas/ bawang putih	Tuber	Ritual of seventh month of pregnancy (**upacara tujuh bulanan**)
Areca catechu L	Arecaceae	Jambe/pinang	Fruit	Ritual of seventh month of pregnancy (**upacara tujuh bulanan**), circumcision (**sunatan/khitanan or nyepitan**)
Arenga pinnata (Wurmb) Merr	Arecaceae	Kawung/aren	Fruit	Ritual of seventh month of pregnancy (**upacara tujuh bulanan**), circumcision (**sunatan/khitanan or nyepitan**)
Bambusa vulgaris Schhrad	Poaceae	Awi hejo/bambu hijau	Stem	Ritual of wedding (**upacara pernikahan**)
Cananga odorata (Lmk) Hook.f.		Kananga	Flower	Ritual of wedding (**upacara pernikahan**)
Carica papaya L	Caricacae	Gedang/pepaya	Fruit	Ritual of seventh month of pregnancy (**upacara tujuh bulanan**), circumcision (**sunatan/khitanan or nyepitan**)
Citrus sinensis (L) Osbeck	Rutaceae	Jeruk	Fruit	Ritual before going to sea (**upacara untuk melaut**)
Cocos nucifera L	Arecaceae	Kalapa hijau/ gading	Fruit	Ritual of baby naming (**upacara pemberian nama bayi/asrokoloan**), before going to sea (**upacara melaut**), planting rice (**upacara tanam padi**)
Coffea robusta	Rubiaceae	Kopi	Seed	Ritual of going to sea (*upacara melaut*)
Curcuma domestica Val	Zingiberaceae	Koneng/kunir	Rhizome	Ritual of wedding (**upacara nikahan**)
Epiphyllum oxipetalum (DC) Haw	Agavaceae	Sedap malem	Flower	Ritual of wedding (**upacara pernikahan**)
Jasminum sambac (L) W.Art	Oleaceae	Malati/melati	Flower	Ritual of wedding (**upacara pernikahan**)
Musa paradisiaca L	Musaceae	Pisang kapas	Fruit	Ritual of baby naming (**upacara pemberian nama bayi/asrokolan**), going to sea (**upacara melaut**)
Nicotiana tabacum L	Solanaceae	Bako/tembakau	Leaf	Ritual of seventh month of pregnancy (**upacara tujuh bulanan**), circumcision (**upacara sunatan/khitanan, nyepitan**), planting rice (**upacara tanam padi**)
Ocimum basilicum L	Lamiaceae	Surawung	Leaf	Ritual of planting rice (**upacara tanam padi**)
Oryza sativa L	Poaceae	Pare/padi	Hulled rice	Ritual of wedding (upacara pernikahan), Ritual of seventh month of pregnanncy (**upacara tujuh bulanan**)
Phaseolus radiatus L	Fabaceae	Kacang hejo/ kacang hijau	Seed	Ritual of seventh month of pregnancy (**upacara tujuh bulanan**)
Phaseolus vulgaris L	Fabaceae	Kacang beureum/ kacang merah	Seed	Ritual of seventh month of pregnancy (**upacara tujuh bulanan**)
Piper betle L	Piperaceae	Daun	Leaf	Ritual of seventh month of pregnancy (**upacara tujuh bulanan**), circumcision (**upacara sunatan/khitanan, nyepitan**)
Pyrus malus L	Rosaceae	Apel	Fruit	Ritual going to sea (**upacara melaut**)
Rosa hybrida Hort	Rosaceae	Mawar	Flower	Ritual of wedding (**upacara pernikahan**)
Vitis vinifera L	Vitaceae	Anggur	Fruit	Ritual of seventh month of pregnancy (**Upacara tujuh bulanan**)
Zea mays L	Poaceae	Jagong	Seed	Ritual of seventh month of pregnancy (**upacara tujuh bulanan**)
Zingiber officinale Roxb	Zingiberaceae	Jahe	Rhizome	Ritual of seventh month of pregnancy (upacara tujuh bulanan), circumcision (**upacara sunatan/khitanan, nyepitan**)
Zingiber purpureum Roscoe	Zingiberaceae	Panglay/bangle	Rhizome	Ritual of seventh month of pregnancy (**upacara tujuh bulanan**)

Figure 4. A homegarden system of the Karangwangi village, Cianjur consisting of various annual and perennial plants, including flowers and fruits used for performing traditional rituals

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The traditional *Rimbo Larangan* system of forest management: An ethnoecological case study in Nagari Paru, Sijujung District, West Sumatra, Indonesia

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Abstract. *Alandra Y. Amelia FUD, Iskandar J. 2018. The traditional Rimbo Larangan system of forest management: An ethnoecological case study in Nagari Paru, Sijujung District, West Sumatra, Indonesia. Asian J Ethnobiol 1: 61-68.* The community of Nagari Paru, Sijunjung District, West Sumatra Province, Indonesia has a traditional forest conservation system locally known as *Rimbo Larangan* which is based on the Local Knowledge (LK) or the Traditional Ecological Knowledge (TEK) - strongly embedded in the local culture.. Although the *Rimbo Larangan* has nearly disappeared in many villages *(nagari*) of West Sumatra, particularly of the Minangkabau ethnic, this traditional forest conservation system in Nagari Paru has been properly maintained. The aim of this study was to document the ecological history, the characteristics of the involved local institutions and the management system of the *Rimbo Larangan* based on a case study in Nagari Paru, Sijunjung district, West Sumatra Province. Method used in this study was qualitative with the ethnoecological approach. The results of the study showed that the ecological story of *Rimbo Larangan* has been established since a long time, in parallel with initial construction of agricultural and settlement areas in the forest. The institution of *Rimbo Larangan,* as a distinctive model, was initially organized by the original initiatives of informal leaders which were later joined and supported by the local government. Based on the *Rimbo Larangan* system, various non-timber forest products of Nagari Paru has been sustainably utilized by the local community. In addition, the forest has provided ecological services over time for the local community.

Keywords: Ethnoecology, Minangkabau, Rimbo Larangan, Traditional forest management, West Sumatra

INTRODUCTION

During the last decades, various aspects of ethnoecology have received scientific attention by different scholars (Iskandar 2004; Jumari et al. 2012; Iskandar and Iskandar 2016). The term ethnoecology may generally be defined as scientific evaluation of local knowledge of people on ecological aspects (Cotton 1996; Iskandar 2012; Iskandar 2004). One of the ethnoecological aspects that has been predominantly studied is the local knowledge (LK) or traditional ecological knowledge (TEK) related to local practices, values, and cosmos or beliefs developed by individuals or communities regarding management of natural resources and environment (Berkes et al. 2000; Toledo 2002). It can be said ~~said~~ that the traditional ecological knowledge (TEK) and beliefs, cosmos or worldview can be considered as important factors in the relationship between social system and ecosystem (Rambo 1983; Toledo 2002). Therefore, the management of natural resources in certain areas will not succeed without the active participation of the local community. It has been widely known that the local people play an active and important role in natural resource management, particularly in management of the village forests (Shrestha and McManus 2006).

The local community of village (*nagari*) of Paru, Sijunjung District, West Sumatra, have deep traditional ecological knowledge (TEK) and sustainable practices of village forest management that is inherited from their ancestors. This traditional forest conservation is locally named as *Rimbo Larangan* and this system has been properly maintained till today. Various factors such as population increase, intensive market economy penetration, and development of technology have predominantly influenced the *Rimbo Larangan* in the West Sumatra Province (cf. Iskandar 2001; Ritchie et al. 2001; Golar 2007; Parrotta et al. 2009).

The traditional law mentioned in the local regulation (*Perda*) of Nagari Paru No.1of year 2002, has imposed some prohibitions, such as prohibition on cutting of trees and hunting of animals based on communal agreement of the community. The local community of Nagari Paru has been allowed to harvest only non-timber forest products (*Hasil Hutan Bukan Kayu/HHBK*). Principally, the aim of the local management of *Rimbo Larangan* is maintaining both quality and quantity of water resources in the forest to fulfill daily human needs and agricultural purposes of the local community, due to the fact that livelihood of Nagari Paru is dominated by farmers, who are particularly engaged in the wet-rice (*sawah*) farming system.

By the application of the *Rimbo Larangan* system, the community of Nagari Paru has successfully maintained the natural resources of village forest by working collectively as an institution. In this paper, three main aspects namely the ecological story, the characteristics local institution, and the management system of the *Rimbo Larangan* in utilizing various non-forest products have been assessed, based on a case study in Nagari Paru, Sijunjung District, West Sumatra Province, Indonesia.

MATERIALS AND METHODS

Location

This research was carried out in a village (*nagari*) called Nagari Paru of Sijunjung District, West Sumatra Province, Indonesia. It is bordered in the east by Nagari Sungai Betung; in the west Nagari Silokek; in the south by Nagari Ai Angek and Solok Ambah; while in the north by Nagari Durian Gadang (Figure 1).

Nagari Paru consists of three *jorong*, namely *Jorong* Batu Ranjau, *Jorong* Bukik Buar and *Jorong* Kampung Tarandam. Total area of Nagari Paru is about 24,026 ha, formed by series of Bukit Barisan that is extending from the northwest to the southeast. The altitude of this area shows variation between 100 m asl and 850 m asl (above sea level). Topographically, Nagari Paru consists of low land of 10,026 ha and approximately 14,000 ha of hills (Monograph of Nagari Paru 2016). Both dry and wetland types of land use, such as the forests, the wet-paddy fields, and rivers are observed here (Figures 2 and 3).

Registered population of Nagari Paru was 1,992 individuals consisting of 493 households, predominantly belonging to the ethnic group called Minangkabau which has 6 sub-ethnics, namely Piliang, Chaniago, Patopang, Malayu Ateh, Malayu Tongah, and Malayu Baruah.

Methods

Method used in this study was qualitative with an ethnoecological approach (Toledo 2002). Techniques, namely observation, and deep interview were used to collect the primary data (Iskandar 2012; Albuquerque et al. 2014). The observation was done to observe ecological conditions of the settlements, agricultural and forest ecosystems. The semi-structured interview or deep interview was undertaken with competent informants who were purposively selected by snowball technique based on categories or categorizations. The competent informants e selected included staff of *Wali Nagari* and several individuals of *Niniak Mamak* or informal leaders and the staff of the local state forestry The data collected by both observation and deep interview was analyzed by cross-checking, summarizing, synthesizing, and making narrative with descriptive and evaluative analysis.

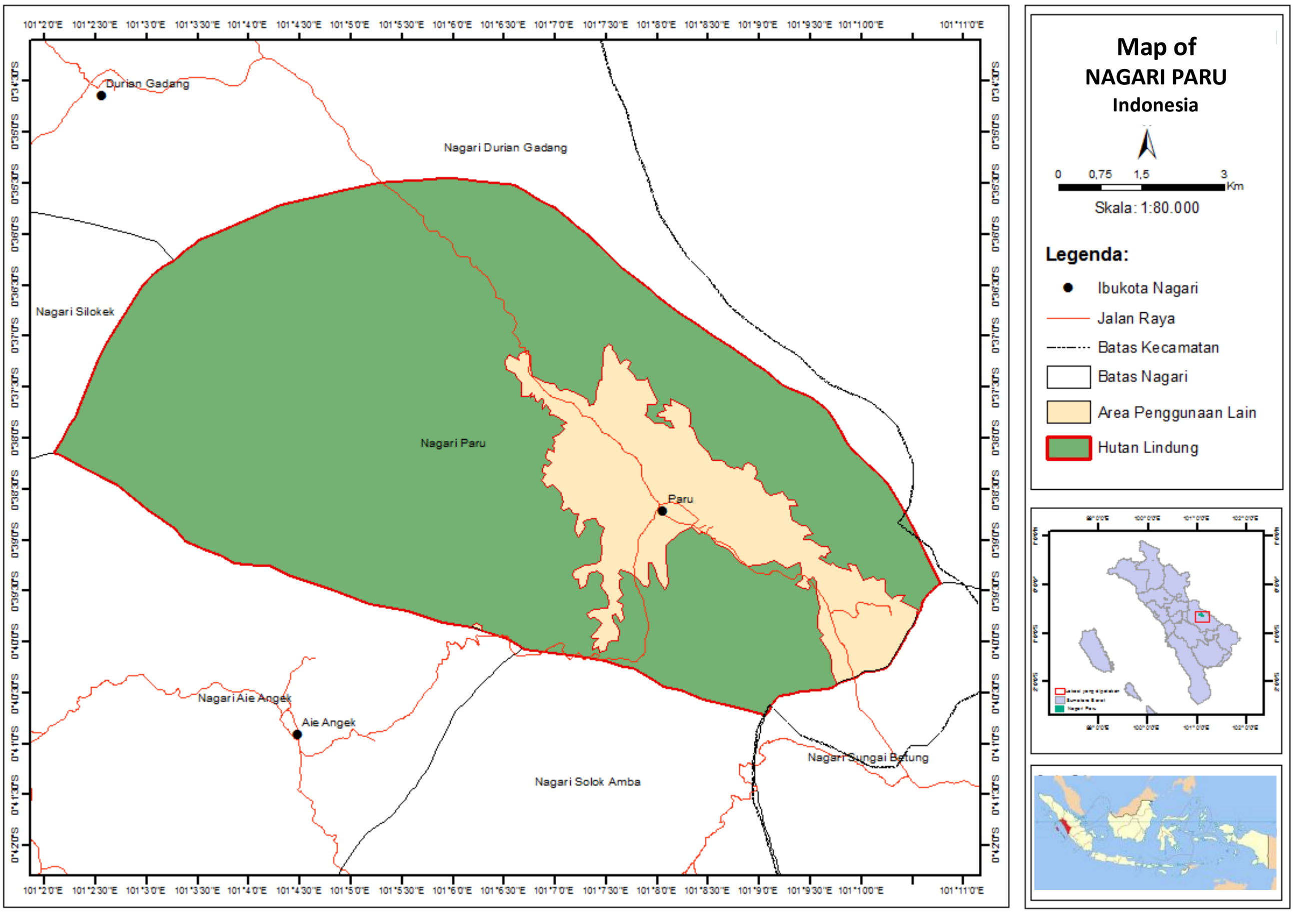

Figure 1. Map of the study area in Nagari Paru, Sijunjung District, West Sumatra Province, Indonesia

Figure 2. Forest and *sawah* of Nagari Paru, Cijunjung District, West Sumatra Province

Figure 3. Upstream of Batang Mangan river of the forest Nagari Paru, Cijunjung District, West Sumatra Province

RESULTS AND DISCUSSION

The story of 'Rimbo Larangan'

According to the local regulation of West Sumatra government, forest (*rimbo*) is considered as one of the wealth of *nagari* of West Sumatra based on a local regulation (*Perda)* of West Sumatra No. 9 year 2000). Story of the *Rimbo Larangan* at Nagari Paru has close relation with the origin of *nagari*. Territory of Nagari Paru was initially established as a '*taratak'*or *bertarak,* a temporary small hamlet, when the local community began looking at the forest land for constructing the wet-rice fields (*sawah*) and swidden fields (*ladang*). Then, it was continuously developed as a new hamlet (*berdusun*) that was the extension of a *taratak.* At that time, due to increase of human population, the houses and the small mosque (*surau*) were initially constructed, and the human population initially resided in non-permanent hamlet. Furthermore, more permanent hamlet (*ber-koto*) that was a settlement that owns *nagari* rights (*hak-hak nagari*) was established. In some aspects, the *koto* had dissociated itself from the *nagari*. In *koto*, a mosque, the traditional house (*rumah gadang*), and traditional leader (*penghulu)* had been established. However, regarding custom affairs and other social affairs, it still had attachment with its initial *nagari*. Subsequently, new *nagari* was formed through traditional discussions with people who had owned the permanent new hamlet (*koto*). Each *nagari* was given a name parallel with the traveling of *Raja Pagaruyung* (*Datuak Rajo Alam*) in his colony areas. The colony areas were frequently visited (*di-parulangi)* by Raja Pagaruyung. Moreover, the area is bestowed on Datuak Bandoro who resides in Nagari Parulang. This area consists of as expressed as 'to right side of land that is named as fourteen of *koto'* (*ka suok tanah darek yang dinamokan ampek baleh koto').* Based on this history, the colony area bestowed to Datuk Bandoro is given name as Nagari Paru that is the origin of word 'parulangan' of Raja Pagaruyung.

Later on, it was given to Datuak Bandaro Kayo who lived in Nagari Parulangan, consisting of the right was the land was named fourteen *koto* (*ka suok tanah darek yang dinamokan ampek baleh koto*). Therefore, the name of *Nagari Paru was based on* the word ***paru****langan* of Raja Pagaruyung.

The founders of *Nagari Paru* has been known as *Datuak Gindo Tamajo*, a *penghulu* (traditional leader) of Patopang ethnic and *Datuak Panji Alam*, a *penghulu* of Malayu Baruah ethnic. According to stories in their community, they initially established *tarak* in approximately the 1500s. Therefore, all land in area of Nagari Paru has been traditionally managed (*di ulayati)* by these ethnics as a communal system. The forest area was divided by the community into two regions, namely Bukik Mandi Angin and Sungai Sirah.

Along with the increase of the population and addition of ethnics in Nagari Paru, both datuk *Datuak Gindo Tamajo* and *Datuak Panji Alam* gave some of the communal lands belonging to their ethnic to four other ethnic group leaders (*penghulu*) s. The giving of the land was only in land tenure status. The land cannot be sold but can be transmitted to their nephews or directly given to their children (Martial 2013) For example, a father (Datuak) of Piliang ethnic can directly give his land to his child of Malayu Ateh ethnic. If his child passed away, all the land will be taken back by Piliang ethnic. In Minangkabau, the communal land (*tanah ulayat*) of ethnic is usually taken by *nagari* for the communal purposes based on the mutual agreement. As a result, the land status changed to be land of *ulayat nagari*. This case is understood due to the communal land (*tanah ulayat*) has several hierarchies as presented in Figure 4. Based on history on transmission or inheritance system of land as mentioned earlier, it can be understood that the communal land (*tanah ulayat)* of Minangkabau has hierarchical levels as presented in Figure 4.

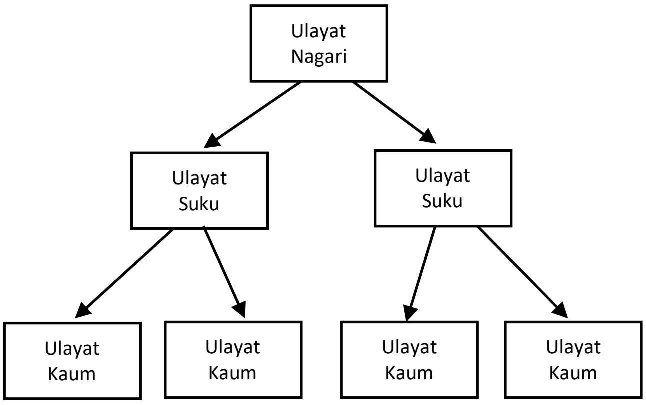

Figure 4. Hierarchy of Tanah Ulayat of Nagari, Minangkabau (Martial 2013)

According to Onrizal and Mansor (2015), before the influence of Western system (the colonial of Dutch), the kingdom of Minangkabau (Pagaruyung) had owned the mature forest conserved in each colony area of *nagari*, as *Rimbo Larangan*. The traditional law and regulation of *Rimbo Larangan* were established as per the old proverb of Minangkabau (Table 1). Interviews with informants revealed that the trees of the forests located around the upper stream of the forest area are not allowed to cut as per the message of the ancestor and are therefore continuously maintained over time by the community. The local community believes that their ancestors had deep understanding of the essential functions of trees grown in the forest, as reserves of water for fulfilling daily needs of the community and also their agricultural farming purposes. It has been understood in line with the old proverb of Minangkabau that nature can be used as teacher (*alam takambang jadi guru*) meaning that humans can learn from nature and its various phenomena which always provide a wisdom.

During the Dutch colonial period, the Dutch government made regulations always based on a special approach that was in correspondence with the existing traditional systems of the local community (Allen 2001). On the basis of interviews during this study, it was learned that during the Dutch colonial period, there was a regulation that trees grown in the upstream location of the forest of Nagari Paru, approximately between 100 meters and 200 meters from the river banks, were not allowed to cut. However, based on the informants' perception, this regulation has mainly provided benefits for the Dutch colonial government, namely decreasing the tax on the agricultural production of the Nagari Paru. Thus, the land right systems of Nagari were changed (Tabel 2). Moreover, after the Indonesian independence, the land right of Nagari Paru also changed (Table 3).

Table 1. Law and custom rule of Rimbo Larangan

In local language of Minangkabau	Meaning in English language
Ka rimbo, kayu indak buliah ditabang, rotan indak buliah dirangguik, manau indak buliah dipancuang	If went to the forest, the woods are not allowed to cut, taking away of the rattans is not allowed, and 'the kind of rare plants *manau*' are not allowed to cut
Ka batang aie, aie indak buliah karuah, batu indak buliah dibaliak, tabiang indak buliah diruntuah	If went to the river, the water is not to be dirty, the stone should not be reversed, and the cliff should not be destroyed
Ka samak baluka, buah manih, buah masam indak buliah diambiak, dipanjek mudo jo lain-lain	If went to shrubs, the sweet fruits, the sour fruits are not allowed to be taken out, and unripe fruits are not allowed to harvest still young harvested, ect.

Note: Onrizal dan Manshor (2015)

Table 2. Status and land control at Nagari Paru in the colonial period

Year	The status of forest	Control
Before 1916	Communal forest (*adat*)	*Penghulu* which was adapted to customary law
1916-1945	There was agreement between the Dutch and Belanda, the traditional leader: The registered forest (HR) and the Ulayat forest (HU)	HR: the Dutch Government HU: *Penghulu* and custom rule

Source: Adapted from Nursidah et al. (2012)

Table 3. Status and s land control at Nagari Paru in the post-Colonial period

Year	The status of forest	Control
1945-1983	The registered forest (HR) The Ulayat forest (HU)	HR: pemerintah HU: penghulu
>1983	Forest state and communal forest, but overlapping between forest state and communal forest	Hutan negara: the government (formal) The community forest: the community and custom rule

Note: Adapted from Nursidah et al. (2012)

In 1982, the forests of Sungai Sirah of Nagari Paru were predominantly cut causing their destruction. It is indicated that a lot of the wet-rice fields were affected by the drought and rice harvesting failures were caused due to the forest destructions. The illegal logging of the forest were undertaken by the domestic and overseas people. Consequently, because extensive illegal logging of the forests was taking place, conflicts between the local community and actors of illegal logging was inevitable. Since a lot of complaints were made by the local people, the all informal leaders (*niniak mamak*) of the Nagari Paru deliberated in the traditional halls of *nagari* (*balai nagari*) and agreed that the forest of Sungai Sirah with a total 500 hectares was established as *Rimbo Larangan*, in 1984. The actors of the overseas illegal logging were expelled. After this incident, in 1985, the people who own the wet-rice fields who were dependent on water from the forest area of Bukik Mandi Angin wanted their forest area of 3,000 hectares to be established as *Rimbo Larangan*. In addition, the establishment of the *Rimbo Larangan* was also aimed to avoid the disaster of landslide r of the main access road to Sijunjung. As a result, the status of land rights in both areas was changed to be the communal land of *nagari* (*tanah ulayat nagari*). The agreement of the establishment of both areas as the *Rimbo* Larangan was not documented in writing, but was orally made among the community members.

In 2002, the establishment of *Rimbo Larangan* of Nagari Paru was regulated by *nagari* regulation of *Pernag* No. 1 of 2002. The *Pernag* is an initiative and results of the agreement of all elements of the local community. The border areas of *Rimbo Larangan* is known only to the local people, due to the absence of any map. After the establishment of the *Pernag* No. 1, 2002, the activities of the illegal logging have continued until 2005. The actors of the logging were predicted by the neighboring community. To respond to this case, *Wali Nagari*, as a chairman of the *Kerapatan Adat Nagari* (*KAN*) and ahead of the *BPAN* (Nagari Paru, Nagari Aie Angek and Nagari Solok Ambah), arranged and signed a letter on the communal agreement as a support from the neighboring community on *Rimbo Larangan* of Nagari Paru. In addition, it has been considered as the socialization of *Pernag* No. 1, 2002 that has been previously arranged. It is aimed to avoid conflicts if there is a violation carried out by the community of neighboring village (*nageri*).

In 2012, the government of Sijunjung District proposed to the central government for *Rimbo Larangan* in Nagari Paru to be established as a forest *nagari* (*hutan nagari).* Two years later, in 2014, this proposal was agreed by the minister of forestry(SK 507/Menhut-II/2014) through a decree of determination of work area (SK Penetapan Areal Kerja/PAK), of approximately 4,500 ha. Moreover, in 2015, it was continued by the Governor of West Sumatra by issuing a decree of the forest management of *Nagari* forest No. 522.4-501-2015 for issuing a forest management definitive permit for 35 years.

Local institution

Good and effective institution will guarantee sustainable utilization and management of natural resources (Ostrom 1990). Ability of local institutions in enforcing the customary law can be seen from the respect of the people to the prevailing customary laws. In this case, the local institution is as *KAN*. Based on interview with informants, it has been revealed that obedience and respect of Nagari Paru community to a customary law in relation with *Rimbo Larangan* is due to the fact that they were traumatized by the impacts of the rampant illegal logging of the 1980s that threatened the continuity of water for its *sawah* farming. This raised awareness in the community about the importance of keeping in maintaining *Rimbo Larangan*. According to Berkes (2004), creation of knowledge about conservation systems can take place because of the resource depletion crisis.

Initially, the relationship between community and customary law in relation to *Rimbo Larangan* is valid with a customary law (*adat salingka nagari*) binding to all community members. However, due to theft of wood that was undertaken by outsiders until 2005, the customary law was made applicable for outsiders as well. According to Martial (2013), institution plays a role to guide interaction among humans, as value system or set rules that apply to the community to facilitate coordination among people in obtaining their expectation quickly.

For conflict resolution in relation with *Rimbo Larangan*, all customary laws are applied only through agreement of *niniak mamak* and nagari government (*pemerintah nagari*). Sanctions are in place related to violation of rules of *Rimbo Larangan.* The customary law offenders should be fined with a cow and an amount of money of 1,500,000 rupiahs, in accordance with the *nagari* customary law of *Pernag* No. 1 year 2002. The sanction of a cow can be replaced by money equal to the cost of a cow. Moreover, the amount collected through fines can be used for the development of the *nagari*.

Conflict resolution mechanism in relation with customary law violation of *Rimbo Larangan* is undertaken gradually, in several steps: (i) The offender is called by an informal ethnic leader (*pengulu sukunya*), (ii) if the offender do not want to pay sanction that has been imposed, the settlement of the case is continued by *niniak mamak* with the government of Nagari Paru, and (iii) if the violator still does not want to pay sanctions, the case will be forwarded to a formal law enforcement agency(police). However, if offender carried out by outsider, the offender will be directly processed by an informal leader (*niniak mamak)* in Nagari Paru and must pay fines. However, if outsider offender do not want to pay fines, the case also be processed by police.

For rural community of Nagari Paru and community of Minangkabau in general, customary sanction is given not only form of material but also form of wide social sanctions. Based on customary law, if someone has committed customary violations, he will not be considered in *nagari*. Consequently, his life will not get peace in the likeness of like a kind of plant that grows on a stone, who lives reluctantly and dies does not want to. It is usually as expressed as follows: if the customary laws are violated someone, it seems as plant upwards cannot grow young leafs, middle part is damaged by insects, live reluctantly, die don't want to, it seems to a plant grows on the rock (*kok pantang dilampaui, ka bawah indak baurek, ka ateh indak bapucuak, ditangah-tangah digiriak kumbang, iduik sagan mati indak namuah, bak karakok tumbuah di batu).*

Regarding management of *Rimbo Larangan*, community of Nagari Paru is always bounded by an old proverb of Minangkabau that a tree trunk has function for lean back, its tendon is a place to sit cross-legged and its leaves as shelter (*batangnyo tampek basanda, ureknyo tampek baselo, daunnyo tampek balinduang*). For the Nagari community, this proverb emphasizes that trees are a main component of the natural forest that must be protected together due to their use for the human life and they also act as protective shields for all community against flooding or landslide which are common due to the topography of Nagari Paru which has steep slopes. In terms of division of work related to management of *Rimbo Larangan,* there can be 4 main groups, namely (i) supervisors/*pengawas* (group of farmers who care for forest/ *Kelompok Petani Peduli Hutan-KPPH*); (ii) supervisor/*pengawas* (*niniak mamak)*; (iii) supervisor/*pengawas* (*pemerintah nagari*); and (iv) supervisor/*pengawas* (community).

The supervisor of group of farmers who care for forest (*KPPH*) is purposively appointed by *Wali Nagari,* to conduct routine patrolling in an area of the Rimbo Larangan, based on a decree letter of Wali Nagari Paru (SK Wali Nagari Paru No. 188.47/05/kpts-Wn-2003). Two persons are also selected from the members of KPPH as *tuo rimbo* who are perceived as people who have better knowledge of various aspects of *Rimbo Larangan,* that each supervisor has a certain working area of Rimbo Larangan Bukik Mandi Angin and Sungai Sirah. The supervisor of KPPH must report to the *nagari* government and *niniak mamak* if they find individuals who violated customary law of *Rimbo Larangan.* The supervision of KPPH is undertaken at least once in every 15 days. Presently, however, the patrolling activity undertaken by the supervisor (KPPH) has decreased to once in 1 month or 2 months.

The supervisor of *niniak mamak* is mainly a person coming from customary units of total 32 individuals (Table 4). Patrolling schedule cannot be fixed for them. They only supervise and patrol based only on their interest to enter *Rimbo Larangan.* The supervisor of *niniak mamak* has the right to direct follow up if they find any violation of customary law of *Rimbo Larangan.*

The supervisor of the *Nagari* government is mainly from staff of Nagari Paru. Like the supervisor of the *niniak mamak*, the supervisor of the Nagari government (*pemerintah nagari*) also cannot be fixed any patrolling schedule or their schedule is uncertain. The *Nagari* government supervisors main duty is to report to *niniak mamak* if found any persons who violated the customary law of *Rimbo Larangan.* Meanwhile, the supervisor of the community (*Pengawas masyarakat*) is mainly from a unit community of Nagari Paru except for the *KPPH*, *Nagari* government, and *niniak mamak*. In general, they are mainly people who frequently enter the forest of *Rimbo Larangan* for harvesting non-timber forest products or usually go to their swidden through the *Limbo Larangan.*

The patrol schedule of supervisor of the community is also cannot be determined. Their duty is to report to Nagari government and *Niniak Mamak* if found any violations of the customary law of *Rimbo Larangan*.

Since establishment of *Rimbo Larangan* as the *Nagari* forest without changing its function as an area of protected forest in 2014, in accordance with the decree letter of the Ministry of the Forestry (*SK Menteri Kehutananan Nomor: SK. 507/Menhut-II/2014*), access of community of Nagari Paru to natural resources, such as non-timber forest products, is guaranteed. Zulaifah (2006) mentions that the sense of belonging to forest will grow if the community is also given access to manage forests. However, the customary law of Nagari Regulation (*Pernag*) No. 1 year 2002 regarding *Rimbo Larangan* has also changed the nature of *Rimbo Larangan* which was initially intended as a local conservation system, wherein nowadays various non-timber forest products are allowed to be utilized.

Table 4. Number of *niniak mamak* in the custom of Nagari Paru

Elements	Position	Name/ title
Urang tuo nan batigo	Urang gadang	Datuak Bandaro Kayo
	Urang tuo	Datuak Syekh Pangulu
	Urang tuo adat	Datuak Suri Dirajo
Ampek jiniah, ethnic of Patopang	Penghulu	Datuak Gindo Tamajo
	Malin	Malin Majo
	Manti	Manti Garang
	Dubalang	Lenggang Majo
Ampek jiniah, ethnic of Chaniago	Penghulu	Datuak Bandaro Hitam
	Malin	Kali Bandaro
	Manti	Manti Ajo
	Dubalang	Pado Intan
Ampek jiniah, ethnic of Piliang	Penghulu	Datuak Mangguang
	Malin	Malin Malelo
	Manti	Manti Kayo
	Dubalang	Lenggang Sutan
Ampek jiniah, ethnic of Malayu Baruah	Penghulu	Datuak Panji Alam
	Malin	Malin Kesa
	Manti	Manti Basa
	Dubalang	Panglimo Gantiang
Ampek jiniah, ethnic of Malayu Tongah	Penghulu	Datuak Gadang Jolelo
	Malin	Malin Cayo
	Manti	Manti Majo
	Dubalang	Paduko Majo
Urang ampek jiniah, ethnic of Malayu Ateh	Penghulu	Datuak Rajo Pangulu
	Malin	Malin Pangulu
	Manti	Manti Manghudun
	Dubalang	Paduko Senego
Datuak angku nan balimo	Imam	Anis (Ethnic of Patopang)
	Khatib	Isyaf (Ethnic of Piliang)
	Bilal	Idrus (Ethnic of Malayu Tongah)
	Kali	Umili (Ethnic of Malayu Baruah)
	Gharin	Ali (Ethnic of Patopang)

However, community of Nagari Paru has never over-utilized non-forest produces, but they have harvested them only in accordance with the needs. They do not take the non-timber forest products that are not used. In this case, the institution of the Nagari government (*KAN)* can pass an ordinance for regulating the utilization of non-timber forest products. According to Rasmussen and Meinzen-Dick (1995), the various aspects of management of resources, including limiting the extent, deciding who can use, allocation rules, and user contribution are arranged by the institution.

There is prohibition on cutting trees of *Limbo Larangan* (Figure 5), but fruits can be harvested. The fruit picking is done by simple method, by using a tool called *pangolan* (similar to punting pole or *galah*). If the fruit trees have grown very tall and its fruits cannot be harvested by *pangolan*, the community members are allowed to climb tree and cut the fruit branches. Except for durian fruits, every body is allowed to pick up ripe durians that fall from the trees. As a result, everyone is not allowed to pick up unripe durian fruits, especially by climbing or throwing the durian to fall.

Concerning harvesting the rattans, the community is not allowed to cut the rattans completely including the supporting trees. Only mature rattans having a length of more than 4 meters can be harvested. The rattans are predominantly used for fulfilling daily needs. They are usually used by the community as rope materials, such as for roping straps of rice nursery fence, house and garden fences, as cloth drying lines; for weaving baskets, mats, and other household utensils (Figure 6).

The community of Nagari Paru is also allowed to harvest various medicinal plants due to their importance in maintaining the household health. In addition, the utilization of clean water from the rivers of *Rimbo Larangan* area, for both agricultural purposes and daily domestic need of the community, is allowed. Catching fishes in rivers of the *Rimbo Larangan* is also permitted. However, use of poisonous materials and electrocution of fishes in the rivers of *Rimbo Larangan* is prohibited. The people of Nagari Paru community are allowed to catch fishes by hand, fishhook or *tangguak* (similar to *seser* or *serokan*). The fish catch is predominantly used for the consumption of the community.

Access to the community of Nagari Paru for collecting fire woods is slightly restricted to the extent that the only the branches of trees that have been broken and fallen on the ground can be collected. Cutting trees for this purpose is not allowed. This prohibition is aimed to avoid environmental destructions in the future. The people are also not allowed to take out the fallen trees from the forest.

Some beliefs related to management of *Rimbo Larangan* also exist in the community, particularly on the presence of a tiger *(inyiak balang)* in the forest. The community believes that tiger *(Panthera tigris sumatrae)* is a border keeping animal. It is not only a forest border keeper but also keeper of the attitude and behavior of the nigari community. For example, if there is a community member has destructed forest or 'do evil' (*maksiat*) of the *Rimbo Larangan*, the community believes that the tiger will come to this customary offender to reprimand the offender. In addition, the community believes in a special sound of siamang *(Symphalangus syndactylus)* which is a sign of disaster. For example, if the people of Nagari Paru hear the noisy sound of siamang - shouting in the forest, they believe that there will be incidents of misfortune, such as disaster or death in the Nagari Paru'. These beliefs and community stories are effective media for educating and awareness creation on values of forest conservation.

In conclusion, based on the ecological or environmental history, the *Rimbo Larangan* has been established for a long time, in parallel with initial construction of the agricultural and settlement areas, by opening the forests. Generally, the community of Nagari Paru has a good understanding of and active participation in conservation and management of *Rimbo Larangan*. This has been expressed in the philosophy of the Minangkabau in *Rimbo Larangan* system. The *Rimbo Larangan* has been continuously maintained over time in line with the customary law practiced by the local community. In addition, because of appropriate system of institutional arrangement which is supported by the government, the *Rimbo Larangan* has provided some benefits for local people. Various non-timber forest products have been continuously utilized over time by the local community of Nagari Paru, Sijunjung District, West Sumatra Province.

Figure 5. Trees of *Rimbo Larangan* of Nagari Paru are prohibited from felling, but non-timber forest products are allowed to be harvested by the community.

Figure 6. Rattans (*Calamus* spp.) are one of the main non-timber forest product harvested from the *Rimbo Larangan* forest.

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SWOT analysis for orchid conservation in a forest at Mount Sanggara, West Java, Indonesia

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Abstract. *Fardhani I, Kisanuki H, Parikesit. 2018. SWOT analysis for orchid conservation in a forest at Mount Sanggara, West Java, Indonesia. Asian J Ethnobiol 1: 69-74.* Mount Sanggara, West Java, Indonesia, specifically in Legok Jero area has orchid diversity consisting of 46 epiphytic and four terrestrial. The diversity indexes (*H'*) were categorized as medium both for epiphytic and terrestrial species. The problems in Mount Sanggara are due to conversion of forest into coffee plantation and illegal logging although the forest status is protected forest. Besides, orchids are also threatened by illegal collecting. Strategic management is needed to solve these problems. The purpose of this study was to create the proper strategies to manage the forest in a sustainable way for orchid species, surrounding villages, company, and the sustainability of the orchid community itself. This paper explores internal and external factors by SWOT analysis to formulate management strategies. Data were gathered by structured and unstructured interview and questionnaire. The instruments were distributed to company as stake holder, farmer group, and local residents. From the SWOT analysis, several strategies were proposed to optimize the strengths and opportunities for the purpose of overcoming the weaknesses and to avoid the threats. Consequently, the proposed strategies can be an alternative for stakeholder to manage this forest sustainably not only for local residents but also for the orchid community itself.

Keywords: Forest conservation, orchid, strategic management, sustainable habitat, SWOT

INTRODUCTION

Orchidaceae is one of the largest families of class angiospermae in the world (Brian and Ritterhausen 1978). Indonesia has 5,000 species out of 25,000 orchid species in total (Gunadi 1986; Banks 2004). There are two major types of orchid species based on the habitat, epiphytic and terrestrial (Hew and Young 2008). Epiphytic orchids attach on host tree trunk for living, while terrestrial orchids grow from inside the soil, humus or litter (Hew and Young 2008).

Java Island has at least 731 species of orchids, 231 are endemic (Comber 1990). In West Java, there are 642 species of orchids (Comber 1990). The habitat loss caused by forest conversion into plantation, farming, and settlement areas has threatened orchid population in Java. Based on data from Forest Watch Indonesia (2014), natural forest cover of Java Island in 2013 declined to 675,000 ha from 1,002,000 ha in 2009. Apart from natural forests, there are limited production forests (394,314 ha) and special function forests (1,562,733 ha). The massive forest conversion is occurring in West Java Province because it is the most populated province in Indonesia with more than 46 million inhabitants (Provincial Office of West Java 2011).

Located at the border between Subang Regency and West Bandung Regency which are included in North Bandung Area (Kawasan Bandung Utara) mountain, several forests are still in good condition. Therefore, the diversity of orchid in this area was also high as reported by Agustina et al. (2008), who identified 41 species of orchids. Based on previous report (Fardhani et al. 2015), Mount Sanggara, specifically in Legok Jero area had orchid diversity consisting of 46 epiphytic and four terrestrial in 0.17 ha study area. Similar researches show the importance of the study of orchid diversity in a certain area in an attempt to conservation (Puspitaningtyas 2007; Tsifis et al. 2007; Yahman 2009; Yulia and Budiharta 2010; Aisah and Istikomah 2014).

The problems to which Mount Sanggara has been exposed are forest conversion into coffee plantation and illegal logging, despite the fact that the forest status is protected forest managed by a government-owned company. Besides, orchid and several plants such as ferns, wild flowers, and pitcher plant, are threatened by illegal collecting. Strategic management is needed to solve these problems. Where local people are interested in the conservation and traditional use of their lands, resources, and so forth, on condition that their fundamental human rights are respected, conflicts do not arise between the people's rights and interests, and the objectives of protected areas (IUCN 2000).

SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis is an instrument for making strategic planning which diagnoses internal strengths and weaknesses of organisations and formulates the opportunities and threats of the environment (Rauch 2007). SWOT is a tool designed to be used in the preliminary stages of decision-making on the one hand and as a precursor to strategic management planning on the other (Srivastava et al. 2005). In this analysis, all factors influencing the operational environment are diagnosed with greater detail (Kotler 1994; Shrestha et al. 2004). This analysis has been widely used in forest environment studies (Pesonen et al. 2001; Rauch 2007; Masozera et al. 2006; Reihanian et al. 2012).

The purpose of this study was to create the proper strategies to manage the forest in sustainable way for orchid species, surrounding villages, company, and the sustainability of the orchid community itself. SWOT analysis could be expected to serve as a proper tool to formulate strategic management planning for orchid conservation in Legok Jero area.

MATERIALS AND METHODS

This study was conducted at Legok Jero Area, Mount Sanggara (6º48'41.47" S; 107º44'43.80"E) and Sunten Jaya village, West Bandung Resident, West Java Province, Indonesia (Figure 1a). Legok Jero was chosen because the abundance of orchid here is the most. The altitude in this area is around 1,700 m a.s.l. The study site is secondary forest with *Schima wallichii* trees as dominant species. Other components are the coffee plantation, in which coffee trees were planted under the shade of canopy trees and the crop fields (Figure 1b). The forest is protected from timber extraction under the management of a government-owned company in forestry. Sunten Jaya village is chosen for this study because the coffee plantation belonged to a farmer group of this village. The coffee plantation is part of a program from the company called Forest Management with Local Community (*Pengelolaan Hutan Bersama Masyarakat*, PHBM). The company allows nearest local community to utilize forest with under shade coffee plantation to avoid forest destruction and illegal logging.

Data were gathered by structured and unstructured interview and questionnaire. The data collections were performed from 10 to 12 August 2015. The sources included the staff of a state-owned company and a head of the farm group. The questionnaire was given to 340 households of Sunten Jaya village including members of farm group during September-October 2015. Interview was held face to face to the company forest manager and head of the farm group. The farm group members and village residents were given questionnaire. In questionnaire, simple Yes/No, multiple choices, and fill-in-the-blank types of questions were used. The questions were kept simple to avoid misunderstanding.

Some of the questioned respondents took the questionnaire home and returned it to the data collector later. This is mainly because they were at work during the day and it was not convenient to fill out the form directly and because they preferred to take time to fill out the questionnaires. However, some other respondents filled the questionnaire directly in front of the collector at the farm.

Management strategies for orchid and its habitat were formulated using SWOT (Strength-Weakness-Opportunity-Threat) analysis. This analysis is representing a systematic and comprehensive diagnosis of factors relating to a new product, technology, management, or planning (Baycheva and Wolfslehner 2015). SWOT matrix, has often been used in the field of business and extended to that of natural resource management in order to assess a given decision, project or policy directive in a systematic manner (Schmoldt et al. 2001 in Reihanian et al. 2012). SWOT analysis doesn't determine whether a strategy is correct or incorrect, but this analysis helps us to arrange several alternatives to overcome problems based on internal factors (strengths and weaknesses) and external factors (opportunities and threat). Applying SWOT analysis provides a good overview and makes it easy to pinpoint important problem areas (Rauch 2007).

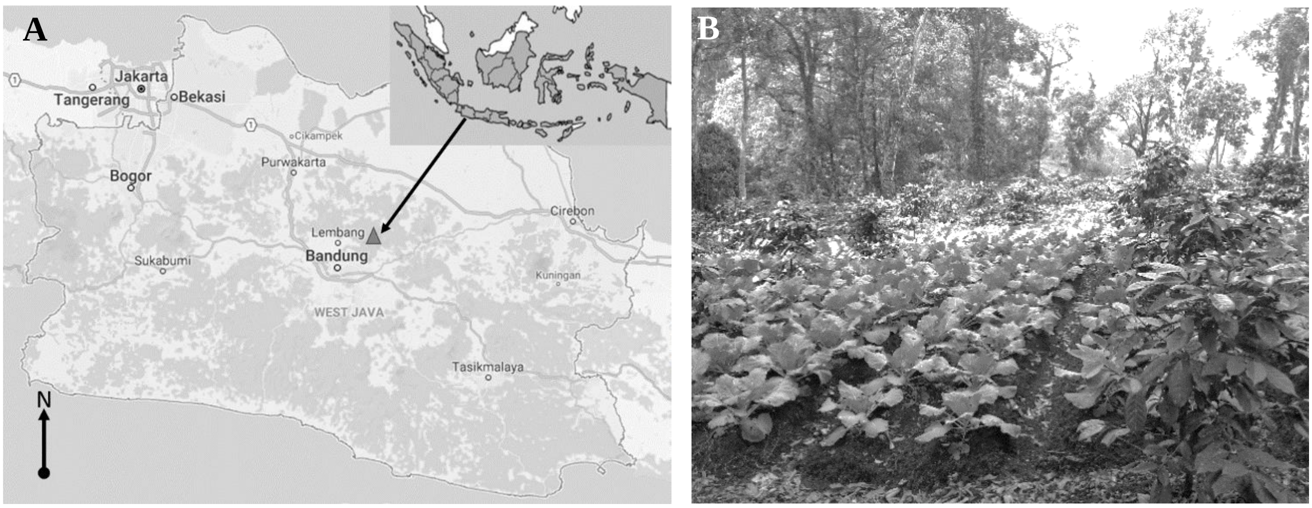

Figure 1.A. Study site map of Mount Sanggara, West Java, Indonesia, B. Crop fields made between coffee tree lines on the cleared forest floor

Both primary and secondary data were the sources for SWOT analysis as shown in Figure 2. The method is based on two tiers of analysis which are conducted separately (Reihanian et al. 2012): (i) First step is to analyse internal factors which contain strengths and weaknesses. (ii) Second step is to analyse external factors which contain relevant opportunities and threats.

The most important part in SWOT is scanning the internal and external factors. The internal factors were classified as strengths (S) and Weaknesses (W). The external factors were classified as Opportunities (O) and Threats (T). Then matrix of Internal Factors Evaluation (IFE) and the matrix of External Factors Evaluation (EFE) were made. The factors then were weighted and calculated to get final score.

The following section describes the process of SWOT analysis:

i. Each factor was given a coefficient between 0 and 1, standing for “not important” and “most important”. The total score of the coefficient in each matrix factor should be equal to 1 in both IFE Matrix and EFE Matrix.
ii. Each factor then scored between 1 and 4. 1 standing for poor, 2 standing for average, 3 standing for above average, 4 standing for superior (Lodato 2014).
iii. Final score of each factor was determined by multiplied coefficient with score.
iv. After total score of each factor was calculated, they were summed to calculate the final score for each matrix (IFE and EFE).
v. For IFE Matrix, if the value was less than 2.5 (below the average), it meant that the strengths were less than the weaknesses; if it was more than 2.5 (above the average), it meant the strength were more than the weaknesses.
vi. For EFE Matrix, if the value was less than 2.5 it meant that the opportunities were less than the threats; if it was more than 2.5, it meant the opportunities were more than the threats (Reihanian et al. 2012; Lodato 2014).
vii. The internal and external factors then were put into SWOT matrix to plan the management strategies (Strength-Opportunity (SO) strategies; Strength-Threat (ST) strategies; Weakness-Opportunity (WO) strategies; Weakness-Threat (WT) strategies).
viii. SWOT matrix was made by pairwise matching of each strength with each opportunity; each strength with each threat; each weakness with each opportunity; and each weakness with each threat.
ix. After matching each factor, the four groups of management strategies were then planned.

RESULT AND DISCUSSION

Internal Factor Evaluation Matrix (IFE)

The IFE Matrix is shown in Table 1. Six factors were identified as strengths of this study site. The weight allocated to these factors ranged from 0.07 to 0.12. The rating scores ranged from 2 to 4. The highest strength factor of this location was ‘the study site status as protected forest’ (weighted score = 0.48). Four factors were detected as weakness of this study site. The weight allocated to these factors ranged from 0.09 to 0.13. The rating scores ranged from 1 to 2. The weakest factor considered from the study site is ‘the low number of terrestrial orchid species’ (weighted score = 0.26). The total score of the IFE Matrix was 2.37, less than 2.5, implying that the strengths were less than weaknesses.

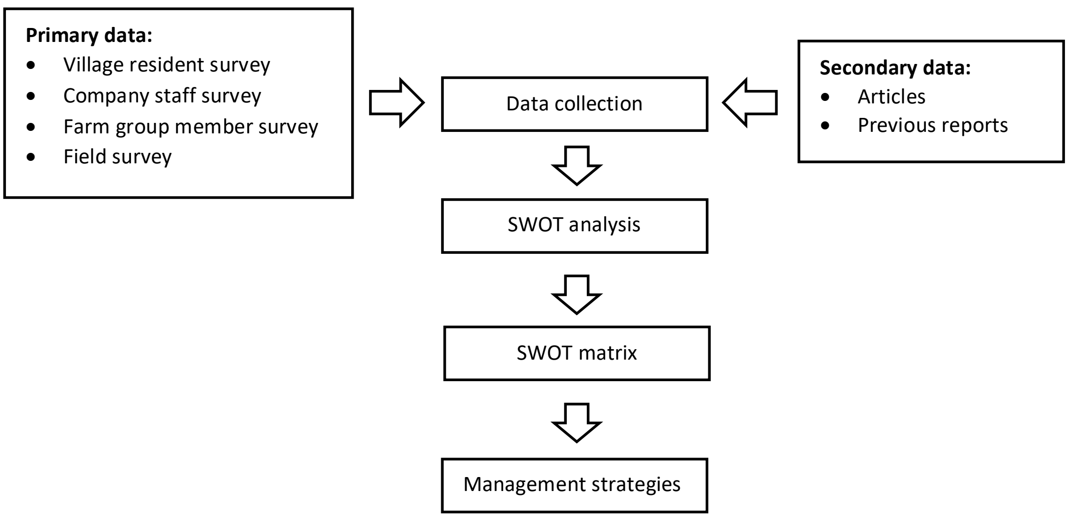

Figure 2. Research methodology outline

Table 1. Internal Factor Evaluation Matrix

	Internal Factor	Code	Weight	Rating	Weighted score
Strengths	The location is protected forest	S1	0.12	4	0.48
	The location is proper habitat for orchid growth	S2	0.10	3	0.30
	High number of epiphytic orchid species (46 species)	S3	0.08	2	0.16
	High abundance of epiphytic orchid.	S4	0.07	4	0.28
	There are 7 epiphytic orchid species endemics to Java Island.	S5	0.10	4	0.40
	Orchid species is distributed evenly.	S6	0.09	2	0.18
Weaknesses	Low number of terrestrial orchid species (4 species)	W1	0.13	2	0.26
	Low abundance of terrestrial orchid	W2	0.12	1	0.12
	There is no economically valuable orchid in study site	W3	0.09	1	0.09
	There is no law protected orchid species in study site	W4	0.10	1	0.10
Total score			1.00	-	2.37

Table 2 External Factor Evaluation Matrix

	External factor	Code	Weight	Rating	Weighted score
Opportunity	PHBM program reduced illegal logging in the location.	O1	0.15	4	0.60
	Local residents would be benefited by PHBM program.	O2	0.13	4	0.52
	Orchids were not considered as main economic commodity for local residents	O3	0.10	3	0.30
	Income of local residents was mostly low (under 100 USD/month).	O4	0.15	3	0.45
	Local residents already knew if the Mount Sanggara forest was orchid habitat	O5	0.07	2	0.14
	Local residents understood if orchid presences needed to be conserved.	O6	0.06	2	0.12
Threat	PHBM program threatens the sustainability of terrestrial orchid.	T1	0.15	4	0.60
	Most of the local residents depended on company forest for daily need.	T2	0.10	3	0.30
	Local residents were not familiar with legally protected orchid species.	T3	0.09	2	0.18
Total score			1.00	-	3.21

External Factor Evaluation Matrix (EFE)

The result of EFE matrix is shown in Table 2. There were six factors identified as opportunities. The weights ranged from 0.06 to 0.15. The rating scores ranged from 2 to 4. The highest opportunity factor of this study site was PHBM program was able to reduce illegal logging in the location' (weighted score = 0.6). Three factors were identified as threats. The weights were ranged from 0.09 to 0.15. The rating scores ranged from 2 to 4. The biggest threat factor considered for this study site was the 'PHBM program threat the sustainability of terrestrial orchid' (weighted score = 0.6). The total score of EFE matrix was 3.21, which would imply that opportunities were more than threat.

In order to overcome the weaknesses and to harness the opportunities, by pair wise matching in SWOT matrix, 14 strategies were proposed for the study site. The proposed strategies were divided into four groups: SO strategies, WO strategies, ST strategies, and WT strategies (Table 3).

Discussion

Applying SWOT analyses provides a good overview and makes it easy to pinpoint important problem areas (Rauch 2007). SWOT analysis helped us to understand the factors (both internal and external) which would affect the forest management, local resident life, and orchids and forest sustainability at the study site where the PHBM program is implemented in West Java Province. We now understood that the PHBM program had important role to reduce illegal and destructive forest utilization. On the other hand, we also understood that the PHBM program might negatively affect the terrestrial orchid species. Forest floor clearance is the major threat for terrestrial orchid conservation besides collecting the wild orchid species (Swarts and Dixon 2009). At the study site, in order to plant coffee trees and crops under the PHBM program, farmer cleared the forest floor including some understory trees (Figure 1b). Not only affecting the terrestrial orchids, research by Hundera et al. (2013) in Ethiopia suggested the intensification of under shaded coffee plantation can reduce the epiphytic orchid species richness by reducing the density of trees and canopy cover.

None of the terrestrial and epiphytic orchids were considered as important or charismatic species at the study site by SWOT analysis (Table 1). However, we cannot let those species extinct only because they are common species. Conservation of common species is needed to ensure that they do not become uncommon or rare and thus can maintain their key ecological and functional roles in an ecosystem (Gaston 2010; Lindenmayer et al. 2011). The implementation of the PHBM program should be carefully conducted to reduce the negative effect.

Table 3 Management strategies for orchid and habitat conservation at Mount Sanggara, West Java, Indonesia

Strength-Opportunity (SO) strategies
- Expand the area of the PHBM program (S1, O1, O2)
- Develop ecotourism area with coffee plantation and orchid habitat for the attractions (S1, S2, S3, S4, S5, S6, O1, O2, O5, O6)
- Promote cultivation of native orchid as new economic commodity for local residents (S2, S3, S4, S5, S6, O3, O4)
- Training program for local residents about native orchid cultivation to increase their income (S2, S3, S4, S5, S6, O3, O4, O6)

Weakness-Opportunity (WO) strategies
- Modify the expansion of coffee plantation to avoid the degradation of terrestrial orchid and other forest floor plants diversity (W1, W2, W4, O1, O2, O6)
- Increase the local resident role in the PHBM program (W3, W4, O1, O2, O4)

Strength-Threat (ST) strategies
- Company has to provide strict supervision related to the PHBM program (S1, S5, T1)
- Secure the forest to avoid illegal utilization (S1, T2)
- Education program for local residents about sustainable forest utilization for their daily needs (S1, S2, T2)
- Company and stakeholder have to provide information to local residents about legally protected orchid to avoid illegal collecting (S5, T3)

Weakness-Threat (WT) strategies
- Termination of extension of coffee plantation area (W1, W2, T1)
- Change the method for coffee planting to be safer for understory, shrub, and ground plants. (W1, W2, T1, T2)
- Re-introduction program to increase terrestrial orchid population (W1, W2, W3, T1)
- Strict law enforcement to avoid destructive and illegal forest utilization (W1, W2, W4, T1, T2)

Note: Codes of each matrix relating to each strategy have been shown in parentheses

Based on the SWOT analysis, we proposed strategic management. All the strategies that were proposed have not been implemented yet. However, these strategies can become an alternative for forest management in this area. We suggest expanding the area of the PHBM program to increase the number of local residents involved so that they would be benefited by the program. The income of local residents is mostly low and depends on the forest for fulfilling daily needs. Increasing the number of local people who are involved in the PHBM program will lead income for more number of households. Local people may be interested in conserving biodiversity only if certain rights to use lands and forests are allocated to them (Harada 2003). Where local people are interested in the conservation and traditional use of their lands, resources, and so forth, on condition that their fundamental human rights are respected, conflicts do not arise between the people's rights and interests, and the objectives of protected areas (IUCN 2000). Agroforestry provides a potentially valuable conservation tool that can be useful for reducing land-use pressure and enhancing rural livelihoods (Bhagwat et al. 2008). However, we also suggest considering about avoiding destructive forest floor clearing that will affect negatively the population of terrestrial orchid and other native plant species.

The area of PHBM program can also be used for ecotourism together with coffee plantation. The natural orchid habitat with many epiphytic species can attract tourist to this area. Such ecotourism can bring lots of benefit to rural zones. Ecotourism in this area may also help to preserve local and traditional value of Sundanese people as part of tourist attraction. Rural tourism will cause the development of social and economic aspect of a village in long terms (Mahmoudi et al. 2011). With ecotourism, the local resident dependency on exploitative forest resources utilization may be controlled.

This study examines the strengths, weakness, opportunities and threats of orchid community in a protected forest area in Mount Sanggara, West Bandung Regency, West Java, Indonesia. Applying SWOT analysis provided a good overview and made it easy to point the important problem areas. From the final score of SWOT analysis, the Internal Factors Evaluation score was 2.37 (<2.5), indicating that the strengths were less than weaknesses. The score of External Factors Evaluation was 3.21, indicating the opportunities were more than threats. Several strategies were proposed to optimize the strengths and the opportunities for the purpose of overcoming the weaknesses and of avoiding the threats. These results may help the forest managers to analyze the problems in the PHBM program implementation for orchids and forest sustainability. The proposed strategies can become an alternative solution for further research on the PHBM program implementation in the study site.

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Antifungal and antibacterial activity of some medicinal plants used traditionally in Kenya

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Abstract. *Jacqueline I, Okemo P, Maingi J, Bii C. 2018. Antifungal and antibacterial activity of some medicinal plants used traditionally in Kenya. Asian J Ethnobiol 2: 75-90.* Many plants have been used by various communities in Kenya in the treatment of bacterial and fungal infections but they have not been validated. The aim of this study was to determine the efficacy of some medicinal plants used by various communities in Kenya that treat the selected bacterial and the selected fungal diseases in man. An ethnobotanical survey was used to select and collect plants from Mwingi North, Kisii South and Rarieda Districts based on their use to treat infectious diseases such as skin infection, diarrhea and many others. Crude extracts from *Zanthoxylum chalybeum, Boscia angustifolia, Melia volkensii, Zanthoxylum gilletii, Fuerstia africana, Urtica dioica, Vernonia amygdalina, Ricinus communis, Commiphora africana, Psiadia punctulata, Senna didymobotrya, Ormocarpum trichocarpum, Sesbania sesban, Balanites aegyptiaca, Albizia coriaria, Ficus sycomorus, Rhus natalensis* and *Tamarindus indica* believed to contain secondary metabolites were screened against ten microorganisms, including the bacteria: *Salmonella typhi* ATCC 19430, *Escherichia coli* ATCC 25922, *Bacillus subtilis, Staphylococcus aureus* ATCC 25923 and Methicillin-resistant *S. aureus* (MRSA). The fungal strains that were used are; *Aspergillus niger*, *Candida albicans* ATCC 90028, *Microsporum gypseum, Cryptococcus neoformans* ATCC 18310 and *Trichophyton mentagrophyte.* The plants were screened using Kirby Bauer disc diffusion method. Phytochemical screening was carried out to identify the presence or absence of classes of bioactive compounds. Data were analyzed using one way ANOVA, significant means were separated using Tukey's test. Generally, *F. africana, Z. chalybeum, B. aegyptiaca, O. trichocarpum, S. didymobotrya* and *T. indica* gave strong antibacterial results of between 14.5 mm and 20 mm as *A. coriaria, F. sycomorus, C. africana, R. natalensis, S. didymobotrya, P. punctulata,* and *T. indica* produced strong antifungal results of between 15.5 mm and 20.5 mm. The results of MICs and the MBCs/MFCs of the extracts of *A. coriaria, F. sycomorus, S. didymobotrya, P. punctulata, F. africana, B. aegyptiaca* and *T. indica* showed good activity of 0.9375 mg/mL in some test cultures. *S. typhi* ATCC 19430 and *E. coli* ATCC 25922 were the least sensitive bacteria while *C. albicans* ATCC 90028 was the least sensitive fungus. The present study indicates that the majority of the plants tested are an important source of antibacterial agents, especially on Gram-positive bacteria (*S. aureus, B. subtilis* and MRSA) and antifungal agents against the dermatophytes, especially *M. gypseum.* This study recommends that the plant extracts with good antimicrobial activity be subjected to pharmacological and toxicological studies.

Keywords: Kenya, medicinal plants, selected bacterial

INTRODUCTION

Around the world, infectious diseases are the major cause of death (Bandow et al. 2003; Parekh and Chanda 2007). Every year, the biggest infectious illnesses account for more than 11 million deaths (WHO 2005). Infectious diseases account for half of all deaths in tropical countries (Okigbo and Mmeka 2008; Assob et al. 2011). Diseases caused by pathogenic bacteria and fungi remain a major public health concern, particularly in developing countries, due to a variety of factors, such as the emergence of bacterial and fungal strains that are resistant to the majority of commonly used antibiotics; the emergence of pathogenic bacteria and fungi that are resistant to the majority of commonly used antibiotics (Abad et al. 2007; WHO 2007). Conventional medications are too expensive, and western health institutions are inaccessible to rural populations (Matu and Staden 2003; Wagate et al. 2008).

Multiple drug resistance has arisen due to the haphazard application of antimicrobials and the re-emergence of diseases caused by genetically diverse microorganisms (Islam et al. 2006; Wagate et al. 2010). As a result of drug resistance, researchers were forced to look for new antibacterial agents from other sources, such as plants (Pirbalouti et al. 2010). Furthermore, because people have evolved alongside plants and our digestive system and physiology are tuned to digesting and utilizing plant-based foods with medicinal value, herbal treatments are far more effective than chemical chemicals in treating human ailments (Farooq 2005).

Medicinal plants have been utilized to treat and prevent human illnesses since the beginning of time because they contain components that have medicinal potential (Parekh and Chanda 2007; Khodadadi et al. 2015). Animals in natural settings, both domesticated and non-domesticated, automatically treat themselves when sick by consuming various components of medicinal plants, such as leaves, stems, bark, and roots (Sindiga et al. 1995). Furthermore, they can heal their skin ailments by vigorously rubbing themselves against medicinal plants that are suitable for their condition (Sindiga et al. 1995). According to research, diets rich in plant-based foods and beverages are connected with a lower risk of developing chronic diseases (Njoroge et al. 2012).

WHO believes that up to 80% of the global population uses plants as their primary source of health treatment (Doughari 2006; Turker and Usta 2008; Verma et al. 2011). Medicinal compounds have been isolated from fungi and higher plants and have proven reliable sources of active ingredients (Olila et al. 2001). Antimalarial, anti-cancer, anti-diabetic, and antibiotic chemicals like atropine and ergometrine, isolated from medicinal plants, are among the most effective medicines (Olila et al. 2001; Samie et al. 2005). In addition, many of the active chemicals used in pharmaceuticals are derived from medicinal plants (Maundu and Tengnas 2005). In light of these findings, it's a good idea to examine local plants that have been utilized to cure illnesses of this nature (Atindehou et al. 2002).

Traditional medicine relies heavily on utilizing medicinal plants, which is a highly profitable business in the global market (WHO 2008). Annual sales of herbal medicine and other plant products in Western Europe amounted to US$5 billion in 2003-2004, US$14 billion for China in 2005, US$160 million in Brazil, and US$100 million in Mexico in 2007 (WHO 2008). Every market in the urban and peri-urban areas of Africa sells medicinal plant parts (Rukangira 2001).

The medicinal value of plants used in traditional medicine is derived from the chemical components, which can treat chronic and frequent bacterial illnesses, respectively (Kareru et al. 2008). In plants, these chemicals are secondary metabolites that act as defensive agents against invading microorganisms and predators (Ghdeib and Shtayeh 1999) and aid in the regulation of plant growth (Nwodo et al. 2010). A variety of secondary metabolites found in plants include alkaloids, steroid hormones, tannins, phenol compounds, flavonoids, and fatty acids (Ashokkumar et al. 2010).

The alarming rate at which new and re-emerging infectious diseases are forming and spreading is a cause for concern. In addition, the development of resistance to antibiotics now in clinical use is another issue that must be addressed (Parekh and Chanda 2007). The prevalence of antibiotic resistance among pathogenic bacteria is predicted to be greater than 70%, with at least one of the antibiotics usually used to treat them being particularly high (Okemo et al. 2011). Due to this, there is an urgent and ongoing need to discover novel antimicrobial compounds with diverse chemical structures and novel modes of action (Parekh and Chanda 2007) and the need to investigate antimicrobial chemicals from alternative sources such as plants (Doughari 2006; Duraipandiyan et al. 2006; Parekh and Chanda 2007).

Many studies on the usage of medicinal plants in Kenya have been conducted, with diverse communities being the focus of the research (Maundu and Tengnas 2005; Kokwaro 2009). The ethnobotany of the Kisii, Rarieda, and Mwingi Districts, on the other hand, is relatively unknown. As a result, additional research should be conducted on plants from the Mwingi district. The rich richness of plants present in the Kisii District provides tremendous opportunities to discover natural products containing antibacterial chemicals. The residents of the Rarieda district also have a strong cultural belief in traditional medicine, which is reflected in their attire (Osewe 2011).

The following goals were set for this study: (i) to determine the antifungal activity of crude plant extracts against standard strains of *Candida albicans*, *Aspergillus niger*, *Trichophyton mentagrophyte*, *Cryptococcus neoformans*, and *Microsporum gypseum*; and (ii) to determine the antifungal activity of crude plant extracts against standard strains of *C. albicans, A. niger, T. mentagrophyte*; (ii) to determine the minimum inhibitory concentrations (MICs), minimum bactericidal concentrations (MBCs), and minimum fungicidal concentrations (MFCs) of crude extracts exhibiting antimicrobial activity against the selected bacterial and fungal pathogens; (iii) to identify the phytochemicals present in the crude extracts and quantify their concentrations.

MATERIALS AND METHODS

Plant materials

A survey was conducted in Katse (Mwingi North), Iyabe and Kerina (Kisii South), Lweya, and Ragengni Divisions in the Rarieda District of Kenya (Figure 1) to identify the most commonly utilized medicinal plants for the treatment of fungal illnesses.

The selection of the plants was based on the ethnobotanical knowledge of the consulted herbalists and the accessible literature. With the help of a semi-structured questionnaire, interviews were performed to acquire indigenous knowledge about plants utilized for the survey. Herbalists who are knowledgeable practitioners were found with the aid of locals and the local authorities and selected as survey respondents (Yinerger and Yewhalaw 2007).

Before conducting the interview, however, formal permission was obtained from each informant (Kasolo et al. 2010). In-home interviews were conducted with them. In the study, respondents were asked for the local names of the medicinal plants they used, the sections utilized, the ailments targeted, the method of preparation, the administration of the resulting preparations, and the availability of the plants.

The species choice-value model was favored because it uses a proportion of all informants who cite a certain number of species for a certain category to determine the most often utilized medicinal plant species (Yinerger and Yewhalaw 2007). Therefore, each prescription was only regarded as following valid verification by three independent sources.

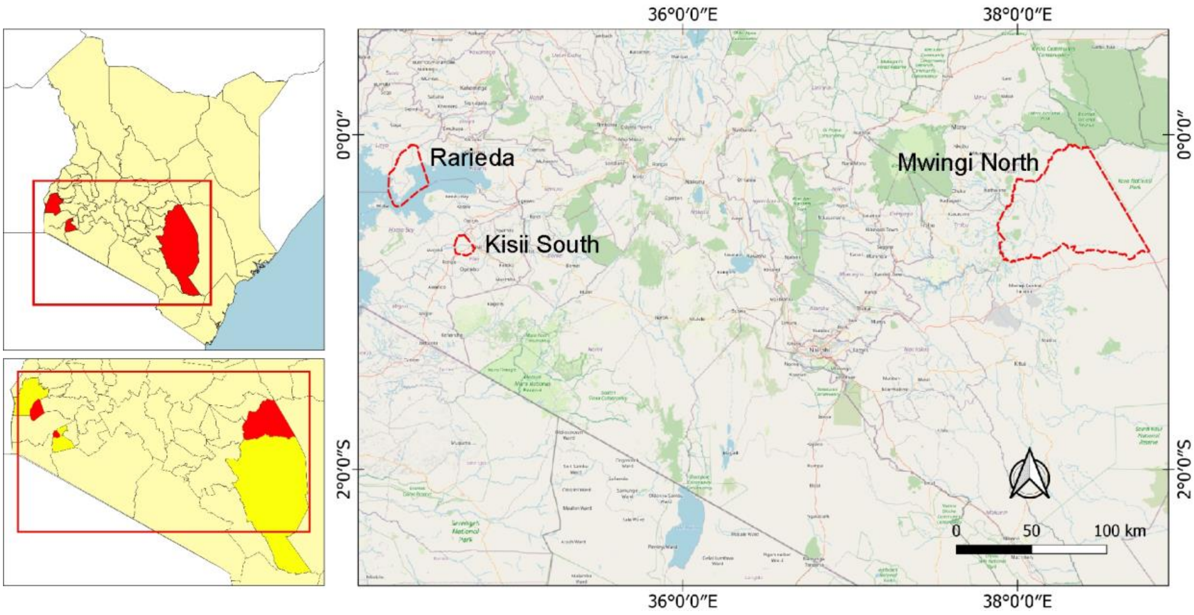

Figure 1. Map of Kenya showing Kisii South, Rarieda, and Mwingi North Districts

Collection and authentication of plant material

In this study, eighteen different medicinal plants, namely, *Zanthoxylum chalybeum* Engl., *Boscia angustifolia* A. Rich, *Melia volkensii* Gürke, *Zanthoxylum gilletii* (De Wild.) Waterman, *Fuerstia africana* T.C.E.Fr., *Urtica dioica* L., *Vernonia amygdalina* Delile, *Ricinus communis* L., *Commiphora africana* (Rich.) Engl., *Psiadia punctulata* (DC.) Oliv. & Hiern ex Vatke, *Senna didymobotrya* (Fresen.) H.S.Irwin & Barneby, *Ormocarpum trichocarpum* (Taub.) Engl., *Sesbania sesban* L., *Balanites aegyptiaca* (L.) Delile, *Albizia coriaria* Welw. ex Oliv., *Ficus sycomorus* L., *Rhus natalensis* Bernh. ex Krauss, and *Tamarindus indica* L. were obtained in Kisii, Rarieda, and Mwingi. The plants gathered were those used to treat gastroenteritis, respiratory ailments, and skin disorders. Fresh plant parts, such as the roots, leaves, and bark, were gathered based on the most frequently employed by traditional healers. Photographs were taken of the selected plant species. A plant taxonomist from the Botany Department, Chiromo, University of Nairobi, Kenya, identified the plants. Collecting voucher specimens and depositing them in the University of Nairobi's herbarium.

Preparation of plant materials

The freshly collected plant parts were thoroughly washed with running tap water, chopped into smaller pieces, and then dried under shade at room temperature for two weeks until completely dry (Matu et al. 2012). Finally, the small pieces were ground into powder at the Botany Department, Chiromo University of Nairobi, using a Wiley mill (model no. 2, USA).

Extraction

The extraction was done at the University of Nairobi, in the Chiromo Department of Chemistry. In a conical flask, 150 grams of each dry powder were mixed with 1000 ml of a 1:1 mixture of methanol and dichloromethane and left overnight (Midiwo 2010; Kitonde et al. 2013). The extracts were then put through a Whatman filter paper No. 1.

Concentration into the solid sample

Dichloromethane and methanol were evaporated in a water bath set to 40°C with a rotary evaporator (Buchii B-205 Switzerland) to make dry organic crude extracts (Omwenga et al. 2009). The paste was put into small vials, then put in an evacuated desiccator with anhydrous copper sulfate to make dry powdered samples. If a bioassay was not done right away, all of the samples were kept in the fridge at a temperature of 4°C.

Microbial test organisms

The microbial test organisms were chosen based on the gathered ethnobotanical information about the disease of interest, their importance as opportunistic pathogens, and their resistance to standard drugs. The chosen microorganisms also cause common infectious diseases that are easy to spread. The standard reference microorganisms and clinical isolates came from the center for Microbiology Research (KEMRI) in Nairobi, Kenya. In this study, the following standard reference microorganisms, environmental microorganisms, and clinical isolates were used:

Fungal isolates
Yeast

C. albicans – ATCC 90028. (i)
C. neoformans – ATCC 18310. (ii)

Dermatophytes

M. gypseum – Clinical isolates. (i)
T. mentagrophytes – Clinical isolates. (ii)

Filamentous fungi

A. niger – Environmental organism. (i)

Maintenance of microbial stock cultures

On Muller Hinton agar no. CMO337, bacterial strains that were already in stock, were grown again (Oxoid Ltd, Basingstoke, Hampshire, England). To get strains that were starting to grow, they were kept at 37°C for 24 hours (Omwenga et al. 2009). Yeasts and molds were grown on Sabaraud Dextrose Agar No. CM 004 by subculturing (Oxoid Ltd Basingstoke, Hampshire, England). Cruz et al. (2007) said that the yeasts were kept at 37°C for 24 hours, the filamentous fungus was kept at 28°C for 48 hours in a humid chamber, and the dermatophytes were kept at 25°C for 72 hours (Korir et al. 2012b). The bacterial and fungal strains were both maintained at a temperature of 4°C.

Antibacterial assays

The antibacterial bioassay was performed by the Kirby Bauer disk diffusion method (Omori et al. 2012). Muller Hinton agar no. CMO337 (Oxoid Ltd, Basingstoke, Hampshire, England) was prepared according to the manufacturer's instructions to culture bacteria. Normal saline solution was used to dilute fresh 24 h culture of bacterial type cultures or clinical isolates to attain a 0.5 McFarland Standard, which gives an equivalent approximate density of 1×10^8 of bacteria (Kitonde et al. 2013). The spread plate method was used to culture 100 µL of the bacterial suspension that was introduced into the petri dishes. Eighteen dry sterile discs (6 mm diameter) were soaked in 100 µL plant extract (made by dissolving 300 mg of each extract in 1000 µL (1 mL) of DMSO). The discs were air-dried and placed aseptically onto the inoculated plates at a distance of 3 mm apart. Discs impregnated with DMSO and then air-dried were used as negative controls, while commercially available discs of chloramphenicol were used as positive control for bacteria. Incubation was carried out at a temperature of 37°C for 24 h. All tests were performed in triplicate. After incubation, bacterial growth inhibition was determined by measuring the diameter zones in millimeters using a transparent ruler and recorded against the corresponding plant extracts (Omwenga et al. 2009; Mariita et al. 2010).

The Kirby Bauer disk diffusion method was used for the antibacterial bioassay (Omori et al. 2012). Oxoid Ltd., Basingstoke, Hampshire, England's Muller Hinton agar no. CMO337 was made according to the manufacturer's instructions so that bacteria could be grown on it. Normal saline solution was used to dilute fresh 24-hour cultures of bacterial type cultures or clinical isolates to reach a 0.5 McFarland Standard, equal to about 1108 bacteria per milliliter (Kitonde et al. 2013). The 100 L of bacterial suspension that was put into the petri dishes was grown using the spread plate method. First, 18 sterile, dry discs with a diameter of 6 mm were soaked in 100 L of plant extract, which was made by dissolving 300 mg of each extract in 1 mL of DMSO. Then, the discs were left to dry in the air and placed 3 mm apart on the inoculated plates cleanly. As negative controls, we used DMSO-soaked and air-dried discs. As positive controls for bacteria, we used discs of chloramphenicol that were available for purchase. During the 24 hours of incubation, the temperature was kept at 37°C. All of the tests were done in triplicate. After incubation, the effectiveness of the plant extracts in inhibiting the development of bacteria was evaluated by using a clear ruler to measure the zone diameter in millimeters and then recording the results against the matching plant extracts (Omwenga et al. 2009; Mariita et al. 2010).

Antifungal assays

To determine the antifungal activity of plant extracts against fungal strains, Sabourand Dextrose Agar no. CM OO4 (Oxoid Ltd, Basingstoke, Hampshire, England) was prepared in accordance with the manufacturer's instructions. Fresh 24 h cultures of fungal type or clinical isolates were diluted with normal saline solution to achieve a McFarland Standard of 0.5. The spread plate method was utilized to culture 100 µL of the fungal suspension that was added to the petri dishes. Eighteen dry, sterile discs (6 mm in diameter) were soaked in 100 µL of plant extract (prepared by dissolving 300 mg of each extract in 1000 µL of DMSO). The discs were air-dried and placed 3 mm apart aseptically on the inoculation plates. Negative controls were discs impregnated with DMSO and air-dried, whereas positive controls were discs containing commercially available miconazole (Bii et al. 2010). The inocula were incubated under conditions where yeast cultures were incubated at 37°C for 24 hours (Cruz et al. 2007), filamentous fungi at 28°C for 48 hours in humid chambers (Costa et al. 2010), and dermatophytes at 25°C for 72 hours in humid chambers (Korir et al. 2012b). In triplicate, all tests were conducted. After incubation, the inhibition of fungal growth was assessed by measuring the diameter zones in millimeters with a transparent ruler and recording the results against the relevant plant extracts (Matu et al. 2012).

Determination of minimum inhibitory concentration

In order to create plant extracts, 300 mg of each crude extract was dissolved in 1000 µL (1 mL) of DMSO. According to the National Committee for Clinical Laboratory Standards (NCCLS), now Clinical Standard Institute (CLSI), the minimum inhibitory concentration of the active crude extracts against the test microorganisms was determined using the broth microdilution method (Korir et al. 2012b).

The experiments were conducted in 96-well microtiter plates. Using serial doubling dilutions, the concentration in each successive well was halved relative to the concentration in the preceding well. Using the disc diffusion method, the MIC was determined only when the plant extract demonstrated high antibacterial activity (≤ 9 mm) (Mariita et al. 2010). Each well received 50 µL of Muller Hinton broth for bacterial strains and 50 µL of Sabourand Dextrose broth. Then, 50 µL of the plant extract (made by dissolving 300 mg of each extract in 1 mL of DMSO) was added to the first well before serial dilutions. The serial dilutions were carried out by transferring 50 µL of the extract-containing Muller Hinton or Sabourand Dextrose broth from the first well to the second, third, and fourth wells. Then, fifty microliters of each test isolate were applied to each well. One row of wells served as the negative control for microorganism growth in the medium, while 50 µL of the antibiotic (Chloramphenicol/miconazole) served as the positive control. Finally, coated microtitres were applied to plates. In humid chambers, bacteria and yeasts were incubated at 37°C for 24 hours (Kitonde et al. 2013), filamentous fungus at 28°C for 48 hours (Costa et al. 2010), and dermatophytes at 25°C for 72 hours (Korir et al. 2012b). Minimum Inhibitory Concentrations (MIC) were determined by noting the lowest concentration of active extracts that inhibited microbiological growth in comparison to the turbidity of the control broth (Kitonde et al. 2013).

Determination of minimum bactericidal / fungicidal concentrations (MBCs/ MFCs)

Bacteria were subcultured on Mueller Hinton Agar, and fungi were subcultured on Sabourand Dextrose Agar from the wells where MIC findings indicated no growth (not turbid). The bacterial and yeast cultures were incubated at 37°C for 24 hours and at 25°C for 72 hours, respectively (Korir et al. 2012b). The MBC is the lowest concentration of plant extracts that did not produce any colony on a solid medium after sub-culturing and incubation for 24 hours for bacteria, 72 hours for dermatophytes, and 24 hours for yeasts. Each test was conducted in triplicate (Samie et al. 2010; Omori et al. 2012).

Statistical analysis

The data were analyzed with Minitab Statistical Software 13.20, 2000. The data analyzed consisted of the average zone of inhibition values for each test culture acquired from the antibacterial and antifungal assays and expressed as standard deviation means. A one-way ANOVA with a 95% confidence interval was performed to assess the significance between the groups. To determine whether there were significant variations between group means, the Tukey's test was run, and a probability value of ≤ 0.05 was considered significant (Mariita et al. 2010).

RESULTS AND DISCUSSION

Ethnobotanical survey

The results of the ethnobotanical survey are presented in Table 1, in which the plants are arranged in alphabetic synopsis according to families. The local names, parts used, drug preparation methods, diseases treated, and the areas where the plants collected are also presented in Table 1.

In this study, 18 species distributed in 15 families were identified. The family reported with the highest number of medicinal plant species was Fabaceae (3 species). It was followed by Rutaceae (2 species). Capparidaceae, Meliaceae, Lamiaceae, Urticaceae, Asteraceae, Moraceae, Balantiaceae, Papilionaceae, Caesalpinaceae, Burseraceae, Compositae, Anacardiaceae, and Euphorbiaceae had one species each.

Eleven plants were collected from Lweya and Ragengni (Rarieda), 4 from Kerina and Iyabe (Kisii South), and 3 from Mwingi North. Various parts were harvested depending on the parts the communities preferred to use to treat various ailments. The most frequently used preparations for administration were concoctions and decoctions. Only 2 plants were preferred by infusion.

The leaves (9 plants) were the most frequently used parts of the plant, followed by the bark (5 plants) and then roots (4 plants). The diseases that were most frequently treated using herbal medicines were gastrointestinal (37%), respiratory (31%), other ailments (18%), skin infection (6%), urinary tract (4%), and wounds (4%) (Figure 2).

Antibacterial activity of the plant crude extracts against standard strains of bacteria

The results indicated that all the plant extracts tested had bacterial inhibitory effects. However, the inhibition of bacteria by the plant extracts varied with different plants. The zones of inhibition between 7 and 10 mm were referred to as low/weak activity, between 11 and 14 moderate activity and between 15 and 21 high/ strong activity.

The plant extracts significantly inhibited the growth of *Bacillus subtilis* and *Staphylococcus aureus* ATCC 25922 compared to other strains of bacteria (Table 2). A total of five plant extracts had high activity against *B. subtilis*. These include; *F. africana* (17 mm), *S. didymobotrya* (16 mm), *O. trichocarpum* (15.5 mm), *Z. chalybeum* (15 mm) and *T. indica* (15 mm), while nine plant extracts had a moderate activity of between 11 and 13 against *B. subtilis*, *R. communis* (13 mm), *B. angustifolia* (13 mm), *A. coriaria* (12 mm), *B. aegyptiaca* (12 mm), *C. africana* (12 mm), *R. natalensis* (11.5 mm), *S. sesban* (11 mm), *P. punctulata* (11 mm) and *Z. chalybeum* (11 mm). The remaining four plant extracts showed weak activity against *B. subtilis*. The *M. volkensii*, *F. sycomorus*, *U. dioica* and *V. amygdalina* produced a weak antibacterial activity of 10 mm, 9.5 mm, 8 mm and 7 mm respectively. The zones of inhibition were significantly different ($P < 0.05$) (Table 2).

For the case of the *S. aureus* ATCC 25923, *F. africana*, *S. didymobotrya*, *T. indica*, *B. aegyptiaca*, *P. punctulata*, *R. natalensis* and *F. sycomorus* gave antibacterial activity of 19 mm, 16 mm, 14.5 mm, 14 mm and 11.5 mm respectively. On the other hand, six plants produced low activity against *S. aureus* ATCC 25923 with a zone of inhibition ranging between 7.5-10mm. For example, *A. coriaria* (10 mm), *C. africana* (9.5 mm), *O. trichocarpum* (8.5 mm), *S. sesban* (8 mm), *Z. gilletii* (8 mm) and *U. dioica* (7.5 mm). All the remaining plant extracts were completely inactive (6 mm). The zones of inhibition were significantly different ($P < 0.05$) (Table 2).

Fuerstia africana is the only plant that showed strong activity with a zone of inhibition of 20 mm against Methicillin-resistant *S. aureus*. The *A. coriaria*, *C. africana* and *S. didymobotrya* Fresen produced moderate activity of 13 mm, 11.5 mm and 11 mm respectively while *V. amygdalina* and *Z. gilletii* gave a low antibacterial activity of 9 mm. All the remaining 11 plant extracts were completely inactive (6 mm) against this test organism. The zones of inhibition were significantly different ($P < 0.05$) (Table 2). In reference to Table 2, all the plant extracts did not show any activity against *Escherichia coli* ATCC 25922 and *Salmonella typhi* ATCC 19430.

Antifungal activity of the plant crude extracts against standard strains of fungus

In vitro testing was performed using the Kirby Bauer disk diffusion method to examine the antifungal capabilities of 18 different plant species against five different fungi. As a result of the observations, it was established that the antifungal activity lay somewhere between 9 and 20.5 millimeters.

Table 3 summarizes how the DCM and methanol extracts of the plants tested stopped the growth of five strains of fungi on average. Some plants, like *P. punctulata* (20.5 mm), *C. africana* (17.5 mm), *S. didymobotrya* (17 mm), *T. indica* (16 mm), *A. coriaria* (16 mm), *F. sycomorus* (15.5 mm) and *R. natalensis* (15.5 mm). On the other hand, *F. africana* had a moderate activity of 13 mm, while *B. angustifolia*, *R. communis*, and *O. trichocarpum* gave low average inhibition zones of 10 mm, 10 mm, and 8.5 mm against the strain. The remaining plant extracts had no detectable action (6 mm) against *M. gypseum*. Significant differences (P<0.05) were found in the areas of inhibition.

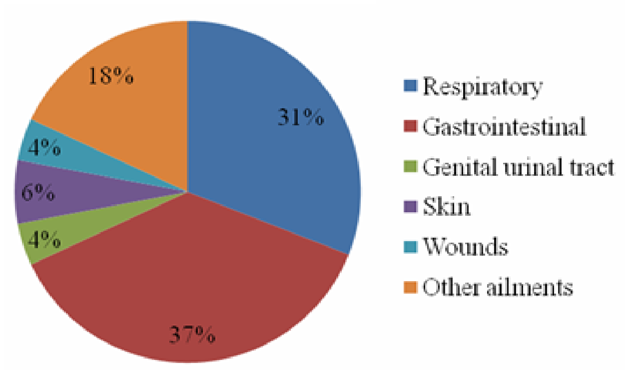

Figure 2. Percentage frequency of diseases treated using herbal drugs in Mwingi North, Kisii South, and Rarieda Districts, Kenya

Table 1. Selected medicinal plants used by the communities from Mwingi North, Kisii South, and Rarieda Districts, Kenya, in treating various bacterial and fungal ailments

Botanical name	Family name and voucher number	Local name	Parts used	Methods	Diseases treated	Area collected
Rhus natalensis Bernh. ex Krauss	Anacardiaceae 2011/IJ018	Sangla (Luo)	Roots	Decoction	Coughs, colds, headache, diarrhea	Lweya (Rarieda)
Vernonia amygdalina Delile	Asteraceae 2011/IJ015	Omosabakwa (Kisii)	Leaves	Concoction	Loss of appetite gastrointestinal problems, diarrhea	Kerina (Kisii South)
Balanites aegyptiaca (L.) Delile	Balantiaceae 2011/IJ05	Othoo (Luo)	Bark	Decoction	Stomach pains, dysentery	Ragengni (Rarieda)
Commiphora africana (Rich.) Engl.	Burseraceae 2011/IJ02	Arupiny (Luo)	Bark	Decoction	Diarrhea fever	Lweya (Rarieda)
Senna didymobotrya (Fresen.) H.S.Irwin & Barneby	Caesalpinaceae 2011/IJ04	Owinu (Luo)	Roots	Decoction	Diarrhea ringworm	Ragengni (Rarieda)
Boscia angustifolia A. Rich	Capparidaceae 2011/IJ017	Mwenzenze (Kamba)	Leaves	Concoction	Chest pains stomachache	Mwingi North
Psiadia punctulata (DC.) Oliv. & Hiern ex Vatke	Compositae 2011/IJ03	Atilili (Luo)	Roots	Decoction	Stomachache, colds, diarrhea	Lweya (Rarieda)
Ricinus communis L.	Euphorbiaceae 2011/IJ01	Odagwa (Luo)	Leaves	Concoction	Stomachache, diarrhea, pains	Lweya (Rarieda)
Tamarindus indica L.	Fabaceae 2011/IJ010	Chwa (Luo)	Bark	Decoction	Diarrhea, cough, fever, tonsils	Ragengni (Rarieda)
Albizia coriaria Welw. ex Oliv.	Fabaceae 2011/IJ08	Ober (Luo)	Bark	Decoction	Cough, diarrhea	Lweya (Rarieda)
Ormocarpum trichocarpum (Taub.) Engl.	Fabaceae 2011/IJ05	Det (Luo)	Leaves	Concoction	Diarrhea, typhoid	Lweya (Rarieda)
Fuerstia africana T.C.E.Fr.	Lamiaceae 2011/IJ011	Ekebunga Baiseke (Kisii)	Leaves	Concoction	Urinary problems, tongue infections, diarrhea, skin infections	Kerina (Kisii South)
Melia volkensii Gürke	Meliaceae 2011/IJ016	Mukau (Kamba)	Leaves	Concoction	Pains in the body	Mwingi North
Ficus sycomorus L.	Moraceae 2011/IJ09	Ngowo (Luo)	Bark	Decoction	Stomach pains, coughs, wounds	Lweya (Rarieda)
Sesbania sesban L.	Papilionaceae 2011/IJ06	Oyieko (Luo)	Roots	Decoction	Diarrheal, diseases, boils	Ragengni (Rarieda)
Zanthoxylum chalybeum Engl.	Rutaceae 2011/IJ013	Mukenea (Kamba)	Leaves	Concoction	Diarrhea, sore throat, coughs, chest pain	Mwingi North
Zanthoxylum gillettii De Wild	Rutaceae 2011/IJ014	Egekoma (Kisii)	Leaves	Infusion	Genitourinary, coughs, mouth ulcers, throat	Kerina (Kisii South)
Urtica dioica L.	Urticaceae 2011/IJ012	Rise (Kisii)	Leaves	Concoction	Blood purification, anemia boils	Iyabe (Kisii South)

Table 2. Zones of inhibition produced by the plant extracts against the selected bacterial strains in mm

Medicinal plants	MRSA	*S. aureus*	*S. typhi*	*E. coli*	*B. subtilis*
Boscia angustifolia	6.0a	6.0a	6.0a	6.0a	13.0b
Fuerstia Africana	20.0d	19.0c	6.0a	6.0a	17.0c
Melia volkensii	6.0a	6.0a	6.0a	6.0a	10.0b
Urtica dioica	6.0a	7.5a	6.0a	6.0a	8.0a
Vernonia amygdalina	9.0b	6.0a	6.0a	6.0a	7.0a
Zanthoxylum chalybeum	6.0a	6.0a	6.0a	6.0a	15.0c
Zanthoxylum gilletti	9.0b	8.0a	6.0a	6.0a	11.0b
Albizia coriaria	13.0c	10.0b	6.0a	6.0a	12.0b
Balanites aegyptiaca	6.0a	14.5c	6.0a	6.0a	12.0b
Commiphora africana	11.5b	9.5a	6.0a	6.0a	12.0b
Ficus sycomorus	8.5b	11.5c	6.0a	6.0a	9.5a
Ormocarpum trichocarpum	6.0a	8.5a	6.0a	6.0a	15.5c
Psiadia punctulata	6.0a	14.0c	6.0a	6.0a	11.0b
Rhus natalensis	6.0a	14.0c	6.0a	6.0a	11.5b
Ricinus communis	6.0a	12.0b	6.0a	6.0a	13.0b
Senna didymobofrya	11.0b	16.0c	6.0a	6.0a	16.0c
Sesbania sesban	6.0a	8.0a	6.0a	6.0a	11.0b
Tamarindus indica	6.0a	16.0c	6.0a	6.0a	15.0c
+ve control	26.0d	24.0d	23.0b	25.5b	26.0d
-ve control	6.0a	6.0a	6.0a	6.0a	6.0a

Table 3. Zones of inhibition produced by plants extracts against fungal strains in mm

Medicinal plants	*C.albicans*	*C. neoformans*	*A. niger*	*T.mentagrophyte*	*M. gypseum*
Boscia angustifolia	6.0a	6.0a	6.0a	6.0a	10.0b
Fuerstia Africana	6.0a	9.0b	8.0a	12.0b	13.0b
Melia volkensii	6.0a	6.0a	6.0a	6.0a	6.0a
Urtica dioica	6.0a	6.0a	6.0a	6.0a	6.0a
Vernonia amygdalina	6.0a	6.0a	6.0a	6.0a	6.0a
Zanthoxylum chalybeum	6.0a	6.0a	6.0a	6.0a	6.0a
Zanthoxylum gilletti	6.0a	6.0a	6.0a	6.0a	6.0a
Albizia coriaria	6.0a	6.0a	6.0a	6.0a	16c
Balanites aegyptiaca	6.0a	6.0a	6.0a	6.0a	6.00a
Commiphora africana	6.0a	6.0a	6.0a	6.0a	17.5c
Ficus sycomorus	6.0a	6.0a	6.0a	6.0a	15.5c
Ormocarpum trichocarpum	6.0a	6.0a	6.0a	6.0a	8.5b
Psiadia punctulata	6.0a	6.0a	6.0a	6.0a	20.5d
Rhus natalensis	6.0a	6.0a	6.0a	6.0a	15.5c
Ricinus communis	6.0a	6.0a	11.5b	6.0a	10.0b
Senna didymobofrya	6.0a	6.0a	6.0a	6.0a	17.0c
Sesbania sesban	6.0a	6.0a	8.0a	6.0a	6.00a
Tamarindus indica	6.0a	6.0a	7.5a	6.0a	16.0c
+ve control	12.5b	13.0c	18,0c	21c	22d
-ve control	6.0a	6.0a	6.0a	6.0a	6.0a

Note: Zones of inhibition in the same column indicated by different letters are significantly different

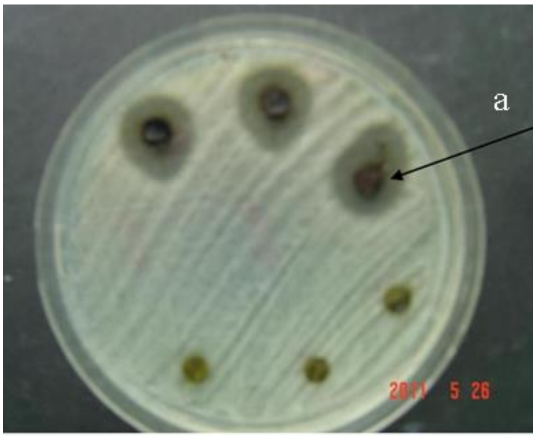

Figure 3. Zones of inhibition of *Commiphora africana* against *Microsporum gypseum*. a. *C. africana*

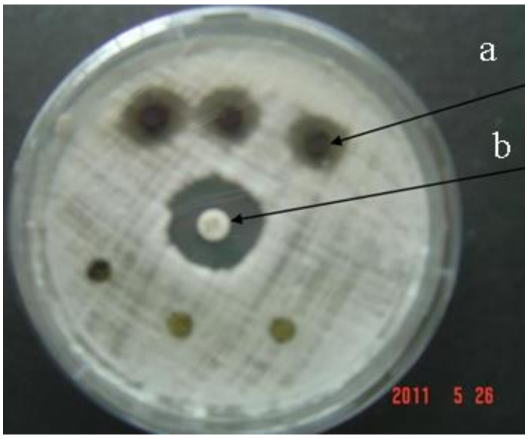

Figure 4. Zones of inhibition of *Rhus natalensis* and that of miconazole control against *Microsporum gypseum*. a. Rhus, b. Miconaz

Table 3 shows that *R. communis* had a moderate effect on *A. niger* (11.5 mm). In contrast, *F. africana*, *S. sesban*, and *T. indica* had low effects (8 mm, 8 mm, and 7.5 mm, respectively). The other 14 plant extracts, namely *Z. chalybeum*, *M. volkensii*, *Z. gilletii*, *F. africana*, *U. dioica*, *V. amygdalina*, *C. africana*, *P. punctulata*, *S. didymobotrya*, *S. sesban*, *B. aegyptiaca*, *A. coriaria*, *F. sycomorus*, *R. natalensis* and *T. indica* had no effect on *A. niger* (6 mm). Significant differences ($P < 0.05$) existed between the inhibition zones.

Fuerstia africana showed weak activity against *C. neoformans* ATCC 18310 with a value of 9 mm and moderate activity against *T. mentagrophyte* with 12 mm. All of the other seventeen plant extracts were completely inactive, making a mean zone of 6 mm (Table 3). All eighteen plant extracts were tested against the organism C. albicans ATCC 90028, and none showed any sign of activity. Figures 3 and 4 display the zones of inhibition that plant extracts have produced against several fungus strains.

The Minimum Inhibitory Concentration (MIC) and the Minimum Bactericidal Concentration (MBC)

As shown in Tables 4 and 5, the broth micro dilution method in a 96-well microtitre plate (Figure 5) was used to determine the minimal inhibitory concentration of plant extracts with inhibition diameters of at least 9 mm.

Six plants had MIC and MBC against MRSA. The *A. coriaria* and *C. africana* gave MIC that were equal to MBC of 1.875 mg/mL. The *F. africana* gave MIC and MBC of 0.9375 mg/mL and 1.875 mg/mL, respectively while *V. amygdalina* and *Z. gilleti* gave MIC and MBC of 3.75 mg/mL and 7.5 mg/mL, respectively while *S. didymobotrya* gave MIC and MBC of 1.875 mg/mL and 3.75 mg/mL, respectively. All the tested plants were screened for MIC and MBC against *B. subtilis* except *U. dioica* and *V. amygdalina*, *F. africana* and *S. didymobotrya* gave a low MIC and MBC against *B. subtilis* of 0.9375 mg/mL which is very close to that of the positive control value 0.4688 mg/mL. The *F. sycomorus* and *M. volkensii* had a weak MIC and MBC of 3.75mg/mL and 7.5 mg/mL, respectively. *Z. gilleti, A. coriaria, B. aegyptiaca, P. punctulata*, *R. natalensis*, *R. communis*, *S. didymobotrya*, *F. africana* had MICs that were equal to MBC.

The *B. aegyptiaca*, *P. punctulata*, *R. communis*, *S. didymobotrya*, *T. indica* and *F. africana* showed a low MIC and MBC of 0.9375 mg/mL against *S. aureus* ATCC 25923. Although the MIC and MBC for positive control were lower, these are promising plant extracts given that they are crude extract compared to pure compounds of the positive control. The *Z. gilleti* showed a high MIC and MBC of 3.75 mg/mL and 7.5 mg/mL respectively and therefore exhibits the lowest activity.

The best MIC and MBC results came from fungal strains, especially *M. gypseum* (Table 5). The results ranged from 0.9375 mg/mL to 3.75 mg/mL, and 7 plants gave a MIC of 0.9375 mg/mL. The *M. gypseum* was consequently the most sensitive of the tested strains. The *P. punctulata*, *A. coriaria*, *C. africana*, *S. didymobotrya*, and *T. indica* exhibited MIC and MFC values of 0.9375 mg/mL.

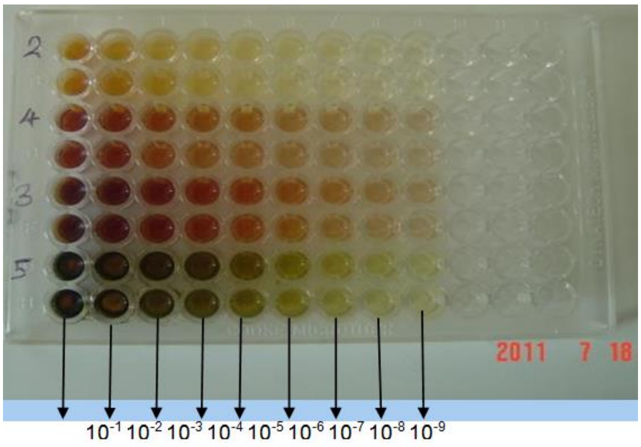

Figure 5. Microtitre plates showing minimum inhibition concentration. The plate shows four extracts at different concentrations beginning from 10^{-1} to 10^{-9} dilution factors

The MIC and MFC values for *F. sycomorus* and *R. natalensis* against *M. gypseum* were different. For both plants, the MIC was 0.9375 mg/mL, and the MFC was 1.875 mg/mL. The activity of *B. angustifolia* and *R. communis* against *M. gypseum* was low, at 3.75 mg/mL for MIC and MFC. It was discovered that only one species of *F. africana*, was effective against both *C. neoformans* and *T. mentagrophyte*. For *C. neoformans*, the MIC and MFC of *F. africana* were 3.75 mg/mL and 7.5 mg/mL. Only *R. communis* was tested for its resistance to *A. niger*. It had a MIC of 3.75 mg/mL and an MFC of 3.75 mg/mL. We did not use any plant extracts for the MIC or MFC screening because every plant tested negative for *C. albicans* ATCC 90028.

Discussion

This study contains information on 18 medicinal plants used to treat, among other conditions, diarrhea, respiratory illness, skin infection, fever, and wounds. The most often mentioned health issue in this study was diarrhea (Figure 2). It could have been caused by drinking polluted water (Jeruto et al. 2008). According to the results of the ethnobotanical study (Table 1), traditional medicine continues to play an important role in treating a variety of disorders for residents of the Mwingi North, Kisii South, and Rarieda Districts.

There are 15 plant families represented by the 18 medicinal plants examined. Concoctions and decoctions were the most commonly utilized preparations for medication methods. A combination of several plants was seen to be used in the preparation of some of the plants. Nanyingi et al. (2008) have backed this up. Because of the synergistic effects of multiple substances in concoctions, the compounds can only be active in combination (Omori et al. 2012).

According to Nanyingi et al. (2008), leaves (9 plants), followed by bark (5 plants), and then roots (4 plants) were the most often used plant parts. The leaves may be chosen since they are the primary photosynthetic organs in plants and produce all of the plant's phytochemical chemicals, which are then transferred to other parts of the plant, such as the bark and roots (Jeruto et al. 2008). As a result of these damaging harvesting procedures, using roots and bark is harmful to the harvested plants' long-term viability (Jeruto et al. 2011).

This investigation suggests significant variation in the antibacterial activity of plant extracts from various species. Some of the medicinal herbs employed by herbalists to treat non-fungal illnesses were also active against certain fungal strains (Tables 2 and 3). Thus, these extracts could be utilized to treat both bacterial and fungal diseases. Examples include *T. indica*, *S. didymobotrya*, *R. natalensis*, *P. punctulata*, *F. sycomorus*, *A. coriaria* and *F. africana* showed strong activity against bacterial and fungal strains. In general, among the examined strains of microorganisms, bacteria were more sensitive to several of the chemicals than fungi (Tables 2 and 3). It is consistent with the findings of Korir et al. (2012b), who observed that bacterial strains were more susceptible to most crude extracts than fungal strains.

Table 4. The minimum inhibitory concentration and the minimum bactericidal concentration for bacterial test cultures in mg/mL

Test culture medicinal plants	*MRSA*		*S. aureus*		*B. subtilis*	
	MIC	**MFC**	**MIC**	**MFC**	**MIC**	**MFC**
Boscia angustifolia	ND	ND	ND	ND	1.875	1.875
Fuerstia africana	0.9375	1.875	0.9375	0.9375	0.9375	0.9375
Melia volkensii	ND	ND	ND	ND	3.75	7.5
Urtica dioica	ND	ND	ND	ND	ND	ND
Vernonia amygdalina	3.75	7.5	ND	ND	ND	ND
Zanthoxylum chalybeum	ND	ND	ND	ND	1.875	3.75
Zanthoxylum gilletti	3.75	7.5	ND	ND	3.75	3.75
Albizia coriaria	1.875	1.875	1.875	3.75	1.875	1.875
Balanites aegyptiaca	ND	ND	0.9375	0.9375	1.875	1.875
Commiphora africana	1.875	1.875	3.75	7.5	1.875	3.75
Ficus sycomorus	ND	ND	1.875	3.75	3.75	75.0
Ormocarpum trichocarpum	ND	ND	ND	ND	0.9375	1.875
Psiadia punctulata	ND	ND	0.9375	0.9375	3.75	3.75
Rhus natalensis	ND	ND	1.875	1.875	3.75	3.75
Ricinus communis	ND	ND	1.875	3.75	1.875	1.875
Senna didymobofrya	1.875	3.75	0.9375	0.9375	0.9375	0.9375
Sesbania sesban	ND	ND	ND	ND	3.75	3.75
Tamarindus indica	ND	ND	0.9375	0.9375	0.9375	1.875
Positive control	0.4688	0.4688	0.4688	0.4688	0.4688	0.4688
Negative control	Growth was observed in all the tubes					

Note: MIC= Minimum Inhibitory concentration, MFC= Minimum fungicidal concentration, ND= Not done

Table 5. The minimum inhibitory concentration and the minimum fungicidal concentration for fungal test cultures in mg/mL

Test culture medicinal plants	*C. neoformans*		*T. mentagrophyte*		*M. gypseum*		*A. niger*	
	MIC	**MFC**	**MIC**	**MFC**	**MIC**	**MFC**	**MIC**	**MFC**
Boscia angustifolia	ND	ND	ND	ND	3.75	3.75	ND	ND
Fuerstia Africana	3.75	7.5	3.75	3.75	1.875	3.75	ND	ND
Melia volkensii	ND	ND	ND	ND	ND	ND	ND	ND
Urtica dioica	ND	ND	ND	ND	ND	ND	ND	ND
Vernonia amygdalina	ND	ND	ND	ND	ND	ND	ND	ND
Zanthoxylum chalybeum	ND	ND	ND	ND	ND	ND	ND	ND
Zanthoxylum gilletti	ND	ND	ND	ND	ND	ND	ND	ND
Albizia coriaria	ND	ND	ND	ND	0.9375	0.9375	ND	ND
Balanites aegyptiaca	ND	ND	ND	ND	ND	ND	ND	ND
Commiphora africana	ND	ND	ND	ND	0.9375	0.9375	ND	ND
Ficus sycomorus	ND	ND	ND	ND	0.9375	1.875	ND	ND
Ormocarpum trichocarpum	ND	ND	ND	ND	ND	ND	ND	ND
Psiadia punctulata	ND	ND	ND	ND	0.9375	0.9375	ND	ND
Rhus natalensis	ND	ND	ND	ND	0.9375	1.875	ND	ND
Ricinus communis	ND	ND	ND	ND	3.75	3.75	3.75	3.75
Senna didymobofrya	ND	ND	ND	ND	0.9375	0.9375	ND	ND
Sesbania sesban	ND	ND	ND	ND	ND	ND	ND	ND
Tamarindus indica	ND	ND	ND	ND	0.9375	0.9375	ND	ND
Positive control	0.4688	0.4688	0.4688	0.4688	0.4688	0.4688	0.4688	0.4688
Negative control	Growth was observed in all the tubes							

Note: MIC= Minimum Inhibitory concentration, MFC= Minimum fungicidal concentration, ND= Not done

The antibacterial activity was more pronounced on the Gram-positive bacteria than on the Gram-negative bacteria, for example; *T. indica, S. didymobotrya, R. natalensis, P. punctulata, A. coriaria, B. aegyptiaca* and *F. africana* produced high antibacterial activity against *S. aureus* ATCC 25923 and *B. subtilis* but no plant extract was active on *E. coli* ATCC 25922 and *S. typhi* ATCC 19430 (Table 2). This is in agreement with previous reports by some researchers (Duraipandiyan et al. 2006; Pirbalouti et al. 2010). The probable reason for the variation in the activities between Gram-negative and Gram-positive bacteria could be due to their morphological difference (Maregesi et al. 2008; Pirbalouti et al. 2010). The Gram-negative bacteria have an extra outer membrane in their cell wall which is richer in lipopolysaccharides and acts as a barrier to foreign substances including antibiotic molecules (Maregesi et al. 2008; Pirbalouti et al. 2010). It is also associated with the enzyme found in periplasmic space which can break down the molecules introduced from outside (Pirbalouti et al. 2010).

Bacillus subtilis and *S. aureus* ATCC 25923 were generally more sensitive to the plants extracts (Plates 6 and 8). This may be explained by the cell wall composition of the Gram-positive bacteria (*S. aureus* and *B. subtilis*) which have a relatively thick layer of peptidoglycan sheets of interconnected glycan chains made up of polymer which is fully permeable to many substances and thus sensitive to most plant extracts (Kitonde et al. 2013). This is supported by Samie et al. (2005) who reported that *Bacillus* spp and *S. aureus* were most sensitive whereas *E. coli* and *Salmonella anatum* were more resistant to crude extracts of plants.

The most powerful plant extract was from *F. africana*. The Kisii often uses it to treat diarrhea, mouth infections, urinary tract problems, and skin infections, among other things. It is supported by the fact that the plant extract has a wide range of effects (Table 1). For MRSA, *S. aureus* ATCC 25923, *B. subtilis*, *C. neoformans* ATCC 18310, *T. mentagrophyte*, and *M. gypseum*, the zones of inhibition were 20, 19, 17, 9, 12, and 13 mm, respectively (Table 2 and 3). Based on these results, the extract of *F. africana* could treat bacterial diseases like boils, sores, wounds, and diarrhea caused by *S. aureus*. This result agrees with the findings of another study (Ng'eny et al. 2011) that found *F. africana* to be active against *S. aureus* and MRSA. It also partly agrees with Mariita et al. (2010), who found that the plant had a moderate effect on *S. aureus* but none on *E. coli, S. typhi*, and *C. albicans*. Possibly, the difference was caused by harvesting times and solvents utilized during the plant's extraction (Samie et al. 2005; Samie et al. 2010; Assob et al. 2011). In the previous work, Mariita et al. (2010) employed methanol as the solvent for extraction, but DCM and methanol in a ratio of 1:1 were used instead in this investigation.

The phytochemical study revealed the presence of all the examined substances. Therefore, its broad spectrum activity can be linked to its phytoconstituents (Doughari and Manzara 2008). Furthermore, tannins and alkaloids are cytotoxic to bacterial cells, which could explain the broad range of activity of *F. africana* (Omwenga et al. 2009).

Only *F. africana* had low activity (9 mm) against *C. neoformans* ATCC 18310 of the 18 plants examined (Table 3). According to Korir et al. (2012a), *C. neoformans* is resistant to all plant extracts. It may be due to galactoxylomannan and glucuronoxylomannan-based polysaccharide capsules (Susane et al. 2009; Teresa and Alspaugh 2012). The virulence and antimicrobial resistance of *C. neoformans* are attributed to the polysaccharide capsular material (Korir et al. 2012a). For example, the expansion of the capsule has been linked to the protection of the host fungus against host defensive mechanisms such as phagocytosis and oxidative burst (Susane et al. 2009). Additionally, capsular material directly acts against the host. In macrophages, *C. neoformans* releases polysaccharides from its capsule into vesicles surrounding the phagosome; accumulation of these vesicles in the cytoplasm of the cell leads to dysfunction and lysis of macrophages (Hansang and Robin 2009).

Senna didymobotrya was active against *S. aureus* ATCC 25923 and *B. subtilis* at a level of 16 mm, and it was active against MRSA at a level of 11 mm. It also worked very well against *M. gypseum* (17 mm), but it did not affect any tested fungal or bacterial strains. It goes against the previous results, which showed that *S. didymobotrya* was active against *E. coli* and *C. albicans* (Korir et al. 2012b). It could be because the plant species came from different places and were collected at different times (Matu and Staden 2003). Plants picked up during the rainy season will not have the same levels of phytochemicals as those picked up during the dry season (Matu and Staden 2003). The phytochemical screening showed that there were a lot of tannins and terpenoids but not many flavonoids. Tannins from the stem bark of *S. didymobotrya* Fresen are known to kill bacteria and other germs (Chothani and Vaghasiya 2011). Tannins work by stopping the production of secretions and making the mucus in the gut more resistant by making protein tannate (Balogun et al. 2011).

Albizia coriaria exhibited antibacterial activity with a zone of inhibition measuring 13 mm against MRSA, 12 mm against *B. subtilis*, and 10 mm against *S. aureus* ATCC 25923; however, it was inactive against *S. typhi* and *E. coli* (Table 2). The *A. coriaria* also had a high antifungal effect on M. gypseum, with a zone of inhibition of 16 mm, but it did not affect the other fungi tested. It was partly in line with the report by Olila et al. (2007), who found that it worked against *B. subtilis* and *E. coli* but not against *S. aureus*. The *C. africana* is also one of the most active plants, showing antimicrobial activity against four microorganisms with zones of inhibition of 11.5 mm, 9.5 mm, 12 mm, and 17.5 mm against MRSA, *S. aureus* ATCC 25923, *B. subtilis*, and *M. gypseum*, respectively. It was partly in line with what Akor and Anjorin (2009) found when they took root extracts and tested them against *S. aureus*, *E. coli*, and *C. albicans*. The different results might be due to the parts of the used plants, physical factors (temperature, light, and water), contamination by field microbes, different plants, and the location (Okigbo and Mmeke 2008).

Tannins, terpenoids, saponins, cardiac glycosides, and flavonoids were found in *A. coriaria* and *C. africana* in varying concentrations, but alkaloids were absent from *C. africana*, according to the results of a phytochemical analysis. Tannins have antibacterial effects due to their capacity to react with proteins to generate water-soluble compounds that are stable and kill bacteria by breaking their cell membranes. This ability allows tannins to form antibacterial compounds (Mariita et al. 2011).

It has been stated that *F. sycomorus* possesses anti-diarrheal properties (Ahmadu et al. 2007). In this research, the bark extract was active against *S. aureus* ATCC 25923 and *B. subtilis*, with zones of inhibition measuring 11.5 mm, 9.5 mm, and 8.5 mm against MRSA (Table 2). In addition, it displayed 15.5 mm of activity against *M. gypseum.* In prior studies, the crude ethanol extract of *F. sycomorus* demonstrated antibacterial efficacy against *S. aureus*, MRSA, and *S. typhi* (Kubmarawa et al. 2007). It partially corroborates the present findings. However, in the present study, it was ineffective against *S. typhi* ATCC 19430. The *F. sycomorus* had no antifungal activity against the yeast species but was highly active against *M. gypseum*.

It was consistent with the findings of Samie et al. (2010), who also found no antifungal activity against yeast. Differences in geographical location, solvents used in extraction, tested microorganisms, parts used, storage conditions, and analysis techniques may account for the variation (Wagate et al. 2008; Olusesan et al. 2010; Obeidat et al. 2012).

Analysis of the phytochemistry of *F. sycomorus* indicated the presence of secondary metabolites, including tannin, cardiac glycosides, terpenoids, and flavonoids. Possibly, the high content of terpenoids contributed to the antibacterial activity. Since this is corroborated by Chiruvella et al. (2007), who extracted terpenoids from *Soymida febrifuga* (Roxb.) Juss. and reported that the antibacterial activity of terpenoids was caused by terpenes disrupting bacterial cell membranes, other researchers have demonstrated the presence of a portion of these chemicals in previous investigations. For instance, it has been established that terpenes and tannins are present in the leaves (Ahmadu et al. 2007). In addition, it has been shown that stem bark extract contains glycosides, tannins, and flavonoids (Kubmarawa et al. 2007).

Zanthoxylum gilletii was effective against *B. subtilis*, MRSA, and *S. aureus* ATCC 25923 but ineffective against *E. coli* 25922 and *S. typhi* ATCC 19430. In addition, it lacked antifungal efficacy against the studied fungi. Mariita et al. (2010) reported that the plant was inactive against *E. coli, S. typhi, S. aureus,* and *C. albicans*, while Agyare et al. (2006) found that the leaf extract of *Z. gilletii* was active against *E. coli, S. aureus, B. subtilis*, and *C. albicans,* but inactive against *A. niger*. The modest discrepancy could be attributable to the solvent employed for extraction and dosing (Okigbo and Mmke 2008) and meteorological and environmental conditions (Kubmarawa et al. 2007; Okigbo and Mmke 2008). Plants harvested at different times and from different areas may have varying antimicrobial properties (Samie et al. 2005). The plant included a high concentration of tannins and flavonoids and a moderate concentration of terpenoids and alkaloids but lacked saponins and cardiac glycosides, as shown by phytochemical analysis. This result is partially consistent with the conclusion reached by Agyare et al. (2006), who discovered that the plant contained alkaloids, tannins, and saponins. Since flavonoids have been shown to have potent antibacterial action, their high content may have been responsible for the observed antimicrobial activity (Olusesan et al. 2010).

Balanites aegyptiaca was effective against *S. aureus* ATCC 25923 and *B. subtilis* but ineffective against MRSA, *S. typhi* ATCC 19430, *E. coli* ATCC 25922, and all tested fungus strains. The flavonoid fractions showed antibacterial activity against *E. coli*, *B. subtilis*, and *S. aureus*. In contrast, the stem bark of *B. aegyptiaca* revealed a high antifungal activity against *C. albicans* (Maregesi et al. 2008). In contrast, the leaves exhibited high antityphoid activity (Doughari et al. 2007). It was discovered that leaf ethanol extracts were more effective against *E. coli*, *B. subtilis, S. aureus,* and *C. albicans* than stem bark extracts (Gour and Kant 2012). The discrepancy could be due to extraction methods, geographical areas where the plants were taken, the part of plant material used, and the period of plant material collection, all of which affected the number of plant constituents (Ibrahim et al. 2009; Okemo et al. 2011) Moreover, extraction techniques may potentially affect the phytochemical makeup of plants (Korir et al. 2012a).

An examination of the phytochemical compounds of the *B. aegyptiaca* plant revealed the absence of tannins. Still, flavonoids, glycosides, terpenoids, saponins, and traces of alkaloids were found. Flavonoids and terpenoids may have contributed to the antibacterial action (Banson and Adeyemo 2007). The high concentration of flavonoids may have contributed to the antibacterial activity, as flavonoids have been shown to inhibit the enzymes involved in pathogen cell wall formation (Negi et al. 2009). The *B. aegyptiaca* has a long history of traditional use for various illnesses (Chothani and Vaghasiya 2011). Therefore, it may have resulted from secondary metabolites in varying quantities (Nwodo et al. 2010).

Tamarindus indica is a plant with more than one use for most of its parts (Caluwe et al. 2010). In the current study, the stem bark extract of *T. indica* was active against *S. aureus* ATCC 25923, *B. subtilis*, and *M. gypseum*, but not against MRSA, *E. coli* ATCC 25923, *S. typhi* ATCC 19430, or the other fungal strains that were tested. Doughari (2006) found that *T. indica* had antimicrobial action against *E. coli*, *S. typhi*, *B. subtilis*, and *S. aureus*. This finding is partially consistent with his findings. Daniyan and Muhammed (2008) found that *T. indica* fruit extract had no effect on *S. typhi* but did affect *E. coli* and *S. aureus*. It is supported by Nwodo et al. (2010), who found that the plant had no effect on *S. typhi* but did have an effect on *E. coli, B. subtilis,* and *S. aureus*. Extraction solvents, collection times, plant ages, the freshness of plant materials, and adulteration may have contributed to these discrepancies in results (Okigbo and Mmeka 2008). It has been demonstrated that various solvents have varying solubility capabilities for certain secondary metabolites (Doughari and Manzara 2008). This study looked at the phytochemical parts like tannins, alkaloids, saponins, cardiac glycosides, and flavonoids. Because of this, the antimicrobial activity can be explained by the phytochemical constituents (Nwodo et al. 2010). Flavonoids have been said to have antimicrobial activity (Olusesan et al. 2010), and their astringent and antimicrobial properties seem to be responsible for their gastric-protective action (Njoroge et al. 2012).

Bacillus subtilis, *S aureus* ATCC 25923 and *M. gypsum*, *R. natalensis*, and *P. punctulata* showed considerable activity in this research. The inhibition zone for *R. natalensis* Krauss was found to be 11.5 mm, 14 mm, and 15.5 mm, respectively. In contrast, *P. punctulata* gave 14 mm, 11 mm, and 20.5 mm, respectively (Table 2). The antifungal and antibacterial chemicals extracted from the plants could be employed to treat disorders caused by *M. gypseum, B. subtilis,* and *S. aureus*. It has been said that *R. natalensis* has antiplasmodial activity (Gathirwa et al. 2011). This product can also protect periodontal germs by preventing bacterial enzyme function. It has been said that *P. punctulata* has antileishmanial properties (Githinji et al. 2009). It was also mildly effective against the fungus that causes coffee berry disease (Midiwo et al. 2002).

The Phytochemical screening indicated that tannins, saponins, cardiac glycosides, terpenoids, and flavonoids were present in *R. natalensis*, but alkaloids were absent. On the other hand, *P. punctulata* possessed tannins, alkaloids, cardiac glycosides, terpenoids and flavonoids but lacked saponins. The known active phytochemical constituents in *P. punctulata* are flavones and phenylpropenoids (Githinji et al. 2010). The antibacterial activity of flavonoids is probably due to their ability to complex with extracellular and soluble proteins and to complex with bacterial cell walls (Banson and Mann, 2008). This could be attributed to the antimicrobial properties of the plant.

The *S. sesban* and *O. trichocarpum* produced zones of inhibition of 11 mm and 15.5 mm, respectively, against *B. subtilis*, indicating moderate activity. Their activity against *S. aureus* ATCC 25923 was mild, at 8 and 8.5 mm. They did not show any action against MRSA, *E. coli* ATCC 25922, *S. typhi* ATCC 19430, the yeast, and dermatophytes, but the leaf extract of *O. trichocarpum* was mildly active against *M. gypseum* (8.5 mm), and the bark extract of *S. sesban* also showed modest activity against *A. niger* of 8 mm. Previous investigations found that the leaves of *S. sesban* had antibacterial activity against *B. cereus, E. coli*, and *A. niger*, which is consistent with the results of this report (Hossain et al. 2007). The *S. sesban* did not affect yeast fungi, but it had a mild activity on filamentous fungi (*A. niger*). This condition may be because the cell walls of the two types of organisms are different (Paiva et al. 2010). The protein in *C. albicans* works as a selective transport system to eliminate wastes and compounds that are destructive to the cell (Nester et al. 2004). An important aspect of medical science is that it permits microorganisms to evade antibiotics and become resistant. The resistance of *C. albicans* ATCC 90028 to crude extracts could be explained in part by this hypothesis.

The phytochemical screening of *O. trichocarpum* showed that it has a lot of terpenoids and flavonoids but no alkaloids or saponins. The *S. sesban* had a lot of tannins, but only a small amount of alkaloids, saponins, cardiac glycosides, and flavonoids. There were no terpenoids. Antimicrobial activity has been attributed to tannins, cardiac glycosides, flavonoids, and saponins (Nwodo et al. 2010). Saponins, for example, disrupt the cell membranes of bacteria, allowing them to enter the body (Omwenga et al. 2009).

Ricinus communis was active against *S. aureus* ATCC 25923, *M. gypsum, A. niger*, and *B. subtilis*, with inhibition zones of 12, 13, 11, and 10 millimeters wide, respectively. On the other hand, the plant was inactive against Gram-negative bacteria and yeast when tested. Although Verma et al. (2011) observed that the root extract of *R. communis* had activity against *S. aureus, B. subtilis,* and *A. niger*, their findings that it was active against *E. coli* contradict those of *R. communis*. According to Jumbo and Enenebeako's (2007) research, the fermented seed extract of *R. communis* is effective against *S. aureus* and *E. coli*. It, too, is in line with current research findings. Different regions and parts of the plant may be responsible for the discrepancy (Arya et al. 2010).

The phytochemical screening of *R. communis* showed a lot of tannins and flavonoids, a moderate amount of cardiac glycosides and terpenoids, and a small number of saponins but no alkaloids. The antimicrobial activities could be caused by the high concentrations of tannins and flavonoids. The ability of tannins to react with proteins to generate stable, water-soluble compounds have been cited as evidence that they may have antibacterial characteristics (Okemo et al. 2011). Flavonoids can potentially interfere with mitochondrial function and cause metabolic obstructions (Williams et al. 2004). Flavonoids and plant products made from flavonoids have been known for a long time to be antimicrobial defense compounds (Korir et al. 2012b). Tannins, which have antifungal, anti-inflammatory, and healing properties, could be blamed for their antimicrobial properties (Moyo et al. 2010). It could explain why *A. niger* has an inhibiting effect.

Vernonia amygdalina was found to be active against MRSA, not so much against *B. subtilis* in this study. The *S. typhi* ATCC 19430, *S. aureus* ATCC 25923, *E. coli* ATCC 25923, and the tested dermatophytes, yeast, and *A. niger* were all inactive in the presence of this antimicrobial substance. Cheruiyot et al. (2009) and Mariita et al. (2010) also found that this plant could not stop *E. coli, S. typhi*, or *C. albicans* from growing. Furthermore, Uzoigwe and Agwa (2011) found that the leaf and stem extracts of *V. Amygdalina* did not kill *E. coli* and *S. aureus*. It is further confirmed by the findings of Uzoigwe and Agwa (2011), who discovered that *E. coli* and *S. aureus* did not show any signs of susceptibility to the leaf and stem extract of *V. amygdalina*. These findings are in direct conflict with those made by Okigbo and Mmeka (2008) and Ogundare (2011) who found *V. amygdalina* to be active in the treatment of *E. coli, S. aureus*, and *C. albicans*, respectively. In the phytochemical examination, the plant was found to have a high concentration of tannins, a moderate concentration of alkaloids, traces of glycosides, and flavonoids, but no saponins or terpenoids at all. As Ogundare (2011) pointed out, this plant may have antibacterial properties because it contains bioactive compounds.

Bacillus subtilis (13 mm) and *M. gypseum* (10 mm) were killed by the leaf extracts of *B. angustifolia*. It was shown that the plant was very weakly active against *S. aureus* and *B. subtilis* but completely inactive against *S. typhi* and *E. coli* in (Omwenga et al. 2009). This discovery was later refuted by Hassan et al. (2006), who reported that root extracts were effective against *E. coli*. There may have been a disparity since different parts of the plant have varying quantities of active phytochemicals (Gathirwa et al. 2011). While the plant includes a wide range of tannins, alkaloids, and flavonoids in varying concentrations, the phytochemical screening indicated that saponins, cardiac glycosides, and terpenoids were missing from the sample. The development of irreversible compounds between tannins and proteins rich in amino acids inhibits cell protein synthesis (Issazadeh et al. 2012). Alkaloids are well-known for their ability to harm cells in other organisms (Issazadeh et al. 2012).

Both *M. volkensii* and *Z. chalybeum* had a zone of inhibition of 10 mm for *B. subtilis*, they did not affect fungal strains (Tables 2 and 3). It is not in line with Akanga (2008), whose study of *M. volkensii* found that it was active against *E. coli*. This study's findings on *Z. chalybeum* agree with those of Matu and Staden (2003), who found that the stem bark exhibited only moderate antibacterial activity against S. aureus. The antibacterial activity of *Z. chalybeum* against *E. coli* and *S. aureus* has been reported to be zero. Moreover, it demonstrated no antifungal effect against *C. albicans* tests (Olila et al. 2001). One theory is that their antidiarrhoea efficacy is due to a synergistic interaction with components from other plants and certain metabolites (Doughari 2006).

Cardiac glycosides, terpenoids, and saponins were found in moderate abundance in *M. volkensii*'s early phytochemical analysis, but alkaloids and flavonols were absent. The *M. volkensii* has tannins, terpenoids and flavonoids, steroids, alkaloids, cardiac glycosides, and saponins at different levels, according to the phytochemical analysis results of Akanga (2008). For *Z. chalybeum*, the phytochemical analysis discovered low concentrations of alkaloids, cardiac glycosides, and terpenoids but moderate concentrations of tannins and flavonoids with no saponins available. It is possible that the antibacterial elements in *M. volkensii* and *Z. chalybeum* simply slowed the growth of *B. subtilis*. Additionally, the drying process may have altered some of the chemical elements of *M. volkensii* and *Z. chalybeum* (Parekh and Chanda 2007).

Urtica dioica had a zone of inhibition of 7.5 mm on *S. aureus* ATCC 25923 and 8 mm on *B. subtilis*, it had no activity on other fungal species tested. It partially agrees with the findings of Uzun et al. (2004). They discovered that the plant was active against *S. aureus*, inhibited *E. coli* considerably, but had no activity on *C. albicans*. No effect on the fungal strains examined, but *U. dioica* may have a role in transporting active chemicals into the blood, stabilizing body temperature, and reducing harmful effects. For this reason, herbalists administer herbal remedies as a cocktail (Adesina 2005; Samie et al. 2010). Because *U. dioica* had little activity against *B. subtilis* (8 mm) and *S. aureus* (7.5 mm), these microorganisms may have developed tolerance to the herb. The crude extract can be increased in concentration to increase the activity. According to Kitonde et al. (2013), if medications have less activity against the test microorganisms, it suggests that the microorganisms have developed resistance to the drug. Antibacterial properties can be enhanced by raising the concentration of the extract. Diluting crude extracts weakens their antimicrobial activity (Ramamoorthy et al. 2010). The phytochemical screening of this plant revealed the absence of saponins, cardiac glycosides, and terpenoids but found traces of tannins, alkaloids, and flavonoids in the plant.

The low antimicrobial activity of this plant may have been caused by the low concentration of bioactive compounds in it (Nwodo et al. 2010). Other things that could explain the low antimicrobial activity besides the lack of active ingredients are the parts of the plant used, the solvent used for extraction, the location where the plants were collected, and the time when the plants were collected (Hamza et al. 2006). The *U. dioica* extract might not work well because there are not enough diffusible compounds (Ibrahim et al. 2009). Other non-active compounds could have been produced due to disintegration reactions induced by the drying process (Omwenga et al. 2009).

Since herbalists blend multiple herbs, the lack of antibacterial activity does not invalidate the ethnobotanical applications of plants. Due to different phytochemicals in different plants, herbalists employ more than one plant to construct a mixture to treat a certain condition (Omwenga et al. 2009). In herbal medicine, "synergy" means that compounds in plants boost each other's effects (Koroishi et al. 2008). However, one plant was used for each bioassay test in this study. The crude extracts are also less effective because they contain impurities (Ogundare 2011).

The minimal inhibitory concentration is a quantitative experiment that offers further information about the potency of the chemicals present in the extracts (Korir et al. 2012b). No plant extract exhibited activity equivalent to or greater than that of the positive control, although growth was seen in all concentrations of the tubes containing the negative control. The high MIC of 0.9375 mg/mL to 3.75 mg/mL for crude extracts compared to 0.4688 mg/mL for standard pharmaceuticals is a strong indicator that the active ingredient in the crude extract was in low concentration, necessitating the usage of large doses of crude extracts to achieve the desired therapeutic benefits (Korir et al. 2012a). The lower the MIC, the more effective the plant extract is against the tested microorganism (Korir et al. 2012b). On a test against MRSA, both *A. coriaria* and *C. africana* had MICs that were equivalent to MBCs of 1.875 mg/mL. It demonstrates that the concentration of *A. coriaria* that suppresses the growth of MRSA is the same concentration that kills the test organism. The *F. africana* MIC and MBC against MRSA were 0.9375 mg/mL and 1.8775 mg/mL, respectively. While the MIC and MBC of *V. amygdalina* and *Z. gilletii* were 3.75 mg/mL and 7.5 mg/mL, respectively, those of *S. didymobotrya* were 1.875 mg/mL and 3.75 mg/mL (Table 4). Low concentrations of crude extracts of medicinal plants reduce treatment duration, overdose, toxicity, and adverse effects (Kitonde et al. 2013).

Except for *U. dioica* and *V. amygdalina*, all tested plants were screened for MIC and MBC against *B. subtilis*. The *F. africana* and *S. didymobotrya* had MIC and MBC values of 0.9375 mg/mL, which was very close to the positive control value of 0.4688 mg/mL. The MIC and MBC of *F. sycomorus* and *M. volkensii* were low at 3.75 mg/mL and 7.5 mg/mL, respectively. MICs for *Z. gilletii*, *A. coriaria*, *B. aegyptiaca*, *P. punctulata*, *R. natalensis*, *R. communis*, *S. didymobotrya*, and *F. africana* were equivalent to MBC. Certain phytochemicals found in the extracts' chemical screening may be responsible for these antimicrobial activities, possibly in combination, as they have been shown to cause cell membrane disruption, resulting in leakage of cellular components and, finally, the death of microorganisms (Marzouk et al. 2010).

Psidia punctulata, *A. coriara*, *C. africana*, *S. didymobotrya* and *T. indica* produced similar activity on MIC and MFC of 0.9375 mg/mL against *M. gypseum*.

These are very promising plants against *M. gypseum*; therefore, they support the use of these plants for skin conditions.

The best MIC and MFC results were obtained with the fungal strain *M. gypseum*. Seven plants have a MIC of 0.9375 mg/mL, with 0.9375 to 3.75 mg/mL. Consequently, *M. gypseum* was the most sensitive of the examined strains. The *P. punctulata, A. coriara, C. africana, S. didymobotrya* and *T. indica* exhibited comparable activity against *M. gypseum*, with MIC and MFC values of 0.9375 mg/mL. In the fight against *M. gypseum*, these plants have shown great promise, which indicates their potential for use in treating skin problems.

The values for MIC and MFC were different for *F. sycomorus* and *R. natalensis*. For both plants, the MIC was 0.9375 mg/mL, and the MFC was 1.875 mg/mL against *M. gypseum*. The *B. angustifolia* and *R. communis* gave MIC and MFC values of 3.75 mg/mL, which is low. Only the *F. africana* plant extract worked against *C. neoformans* and *T. mentagrophytes*. Its MIC and MFC against *T. mentagrophytes* were both 3.75 mg/mL, and its MIC and MFC against *C. neoformans* 18310 were only 3.75 mg/mL and 7.5 mg/mL, respectively (Table 5). It may result from a high concentration of terpenoids, which have cytotoxic properties against bacteria and fungi (Mamta and Jyoti 2012). The only plant tested against *A. niger* that had a MIC and MFC of 3.75 mg/mL was *R. communis*. Those high values show that the plant extracts have less sensitivity to the microorganisms (Obeidat et al. 2012). Because all plants were negative on *C. albicans* ATCC 90028, no plant extracts were tested for MIC and MFC. It could have been caused by the biofilms that *C. albicans* ATCC 90028 produces when a single cell sticks to a surface and grows into a microcolony. When these microcolonies join, they form a complex 3D structure held by hyphae and an exopolymer matrix (Lafleur 2011).

The highest MIC and MBC/MFC values of the test microbes are an indication that either the plant extracts have low activity on the tested bacterial and fungal strains or that the microorganisms have the potential of developing antibiotic resistance, while the low MIC and MBC/MFC values for the tested microbe is an indication that the plant extracts have the potential to treat any diseases associated with the pathogenic microbes effectively (Doughari 2006; Doughari and Manzara 2008). In this research, all the active plant extracts were bacteriostatic/fungistatic since antibacterial substances are considered bactericidal agents when the ratio of MBC/MIC is ≤ 4 and bacteriostatic agents when the ratio of MBC/MIC is ≥ 4 (Gatsing and Adoga 2007).

The highest MIC and MBC/MFC values of the test microbes indicate either that the plant extracts have limited activity on the tested bacterial and fungal strains or that the microorganisms can develop antibiotic resistance. In contrast, the lowest MIC and MBC/MFC values for the tested microbe indicate that the plant extracts can effectively treat any ailments caused by the pathogenic microbes (Doughari 2006; Doughari and Manzara 2008). All of the active plant extracts in this study were bacteriostatic or fungistatic. Antibacterial substances are called bactericidal agents when the ratio MBC/MIC is ≤ 4 and bacteriostatic agents when the ratio MBC/MIC is ≥ 4 (Gatsing and Adoga 2007).

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