INTERNATIONAL JOURNAL OF PLANT, ANIMAL AND ENVIRONMENTAL SCIENCES

IJPAES

Volume-6, Issue-3, July-Sep-2016 Coden: IJPAJX-CAS-USA, Copyrights@2016 ISSN-2231-4490

Received: 14th Mar-2016 ***Revised: 13th May-2016*** ***Accepted: 20th May-2016***

Research article

ASSESSMENT OF THE ECOLOGICAL DISTRIBUTION, SPECIES DIVERSITY AND ABUNDANCE OF MEDICINAL PLANTS IN CENTRAL KAJIADO, KAJIADO COUNTY, KENYA

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ABSTRACT

The study was conducted with the aim of assessing the composition, distribution, abundance and the community structure of local medicinal plants in Kenya Marble Quarry (KMQ), Mile 46 and Oltepesi at Central Kajiado, Kenya. Relative abundances of species in the three research sites were highest for *Balanites aegyptiaca* (36.92%) in KMQ, *Commiphora africana* (28.41%) and *Balanites aegypitaca* (27.27%) followed by *Acacia drepanolobium* (21.6%) in Mile 46, while in Oltepesi, *Balanites aegyptiaca* (39.4%) was the dominant species. This indicated that the area was dominated by only few medicinal plant species even if no significant differences were observed statistically between the sites in the relative abundance of the species (df=2, P=0.069, α=0.05). At Mile 46 and KMQ all the species had a contagious distribution while in Oltepesi, one species *Albizia anthelmintica* showed a regular distribution. In Oltepesi area, lower species diversity and evenness were recorded as compared to the other areas, namely Mile 46 and Kenya Marble Quarry (KMQ) though no significant differences (df=2, P=0.259, α=0.05) were noted between the sites. The species diversity of the species in the area was homogenous type of plant species.

Keywords: Abundance; Composition; Distribution; Kenya; Medicinal plants

INTRODUCTION

Approximately 85% of the world's population relies on traditional medical treatments based on plant remedies (plant and plant products), and around 25% of the world's pharmaceutical medicines demands are derived from plants [1]. According to the World Health Organization (WHO), approximately 3.5 billion people in developing countries believe in the efficiency of plant remedies and use them regularly [2] and it has also been estimated that up to 80% of the population in developing countries rely on the use of medicinal plants to help meet their primary health care needs [3].

More than 70% of the Kenyan population relies on traditional medicine as its primary source of health care, while more than 90% use medicinal plants at one time or another [4,5]. For many local communities in Kenya, traditional medicine is less expensive, more locally available, and more culturally accepted than modern conventional medicine [5] and more than 1200 plants are described as medicinal plants from a flora of approximately 10,000 members [6]. The wide spread use and acceptability of the traditional medicinal value of plants in both urban and rural society in Kenya could be attributed to culture, efficacy against some diseases, accessibility and affordability as compared to modern medicine. This traditional medical system is characterized by variation in socio-cultural background, ecological diversity of the country as well as ethnic group and this knowledge of traditional medicine is usually passed from generation to generation through word of mouth [7].

The increasing interest of using medicinal plants combined with continued habitat loss and erosion of traditional knowledge, is endangering many important medicinal plant species and populations and creating an urgent need for improved methods of conservation and sustainable use of these vital plant resources [5]. Destructive harvesting techniques, overexploitation, habitat loss, and habitat change are the primary threats to medicinal plant resources [8] the plant parts used and the manner in which medicinal products are harvested also affect population structure and availability. Particularly vulnerable are those species occurring at low densities, those whose roots are harvested, and those whose bark or oil is extracted unsustainably [9,10].

Most of the plants used in traditional medicine are collected from the wild, and only a few have been domesticated. There is, therefore, a real danger of genetic erosion, which in turn calls for the need for collection and conservation, research on propagation and cultivation, and investigation into possible modifications in the active ingredients due to changes in the growing environment. For conservation of rare plant species, cultivation is often considered an alternative to wild collection [11].

According to Ref. [12], the conservation of African medicinal plant species is critical for local health as well as for international drug development. As much as 95% of African drug needs comes from medicinal plants, and as many as 5000 plant species in Africa are used medicinally [12]. The world's flora and fauna are facing an alarming decline of its wild populations, mainly due to the loss of their natural existing habitats. A lack of ecological knowledge can seriously hinder the conservation and sustainable use of medicinal plant species, especially in the face of anthropogenic threats such as overexploitation and land use change.

The insufficient knowledge about the ecological distribution and abundance of medicinal plants is a serious problem for resource managers. The creation of protected areas may facilitate the conservation of medicinal plant species by reducing habitat loss and via restrictions on access and extractive use, reducing disturbance and overexploitation [13,14].

Apart from threatening the communities' knowledge on traditional medicine, changing lifestyles and practices [15] are also affecting the status of medicinal plants themselves. It is generally agreed that in the less developed countries like those of Africa, human activities are taking a serious toll on renewable resources including plant species that are valuable to rural communities [16]. Deforestation is one of such activities and has led to tremendous loss of important plant resources in both the developed and developing countries. Tremendous land use changes have taken place in the recent past which has seen agriculture become popularized [17], and this has the potential to undermine the conservation of important plant resources to the community.

The primary causes of deforestation include the clearance of land for agriculture which comes as a result of increasing pressures to increase agricultural production and the harvesting of wood for fuel. Wood fuels (including wood and charcoal) constitute between 75% and 95% of the energy balance for all the countries in East Africa [18]. Thus, wood fuel consumption places a major pressure on forest resources. Unfortunately, according to a recent report, almost one third of medicinal plant species could become extinct, with losses reported in China, India, Kenya, Nepal, Tanzania and Uganda [19]. Greater losses are expected to occur in arid and semi-arid areas due to factors such as: climate change, erosion, expansion of agricultural land, wood consumption, and exploitation of natural vegetation, increased global trade in natural resources, domestication, selection and grazing among other factors [20].

The objective of this study was to determine ecological parameters that characterize medicinal plants and their contribution to primary health care of rural communities in central Kajiado County, Kenya. The specific objectives were to (i) assess the composition, distribution and abundance of Indigenous Medicinal Plants in central Kajiado County and (ii) asses the community structure (species richness and diversity) of local medicinal plants.

Study Area, Material and Methodology

Study area

The study was carried out at Central Kajiado in Kajiado County, Kenya at selected three sites; i) Oltepesi, ii) Elangata-Wuas (Mile 46), and iii) Kenya Marble Quarry (KMQ), located at the southern end of the Rift Valley Province (Figure 1). Kajiado county is bordered by the Republic of Tanzania to the Southwest; and is situated between longitudes 36°5' and 37°55' East and latitudes 1°10' and 3°10' South. The district lies in the rain shadow of Mount Kilimanjaro and has semi-arid climate. Annual rainfall has a bimodal distribution pattern with precipitation usually occurring during the period between November and January (short rains) and March to May (long rains). The mean annual rainfall is low (350 mm) and daily temperature ranges from 35°C in February and March to 12°C in July [21].

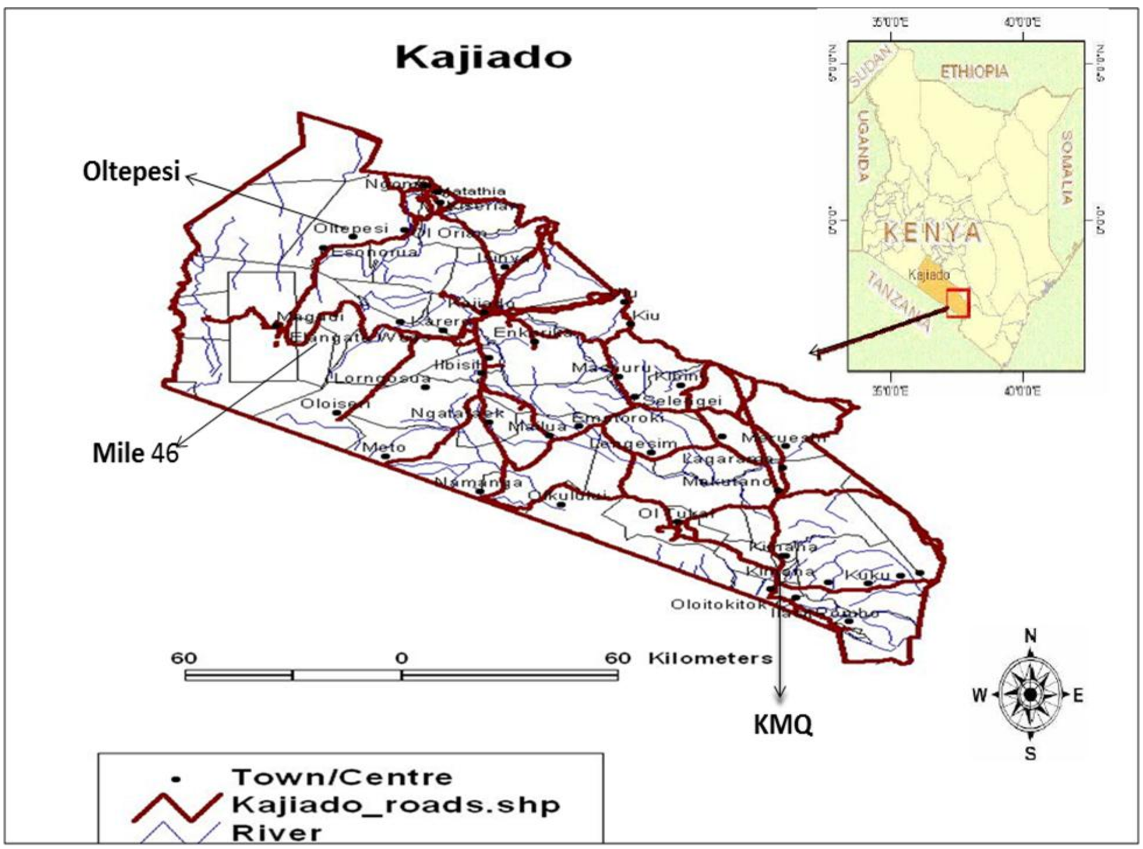

Figure 1: Map of the study area showing the three sampling sites (Source: Department of Geography and Environmental studies, University of Nairobi).

The average land elevation lies below 1600 m and it is characterized by shallow soils and ground vegetation cover ranging from zero to 85%. The natural vegetation occurred in the form bushed grassland, bush land and open woodland, especially in the seasonal river valleys (Table 1).

Table 1: Geographical location of the study sites in Central Kajiado, Kajiado County, Kenya.

Site name	GPS Location	Site elevation (m)	Habitat
Kenya Marble Quarry	S 01^o 55.241\`, E 036$^o$ 38.176\`	1534 - 1598	Open woodland
Mile 46	S 01^o 53.547\`, E 036$^o$ 35.217\`	1410 - 1424	Open woodland
Oltepesi	S 01^o 58.626\`, E 036^o 36. 873	1409 - 1410	Open grassland & woodland

MATERIALS AND METHODS

Ground reconnaissance was conducted by walking across the area, on motorable tracks and on foot through tracks. A GPS was used to locate the research sites and sampling transects and plots were set up across the available vegetation types in the Kenya marble, Mile 46 and at Oltepesi. Sampling plots measuring 10 × 10 m were established within each 100 m transect erected at each of the study sites. The transect in Mile 46 was 2.1 km long and the last transect in Kenya marble Quarry (KMQ) and Oltepesi was 2 km long. A total of 21 plots were set up at the main study site at mile 46 and a total of 20 plots Kenya Marble Quarry and Oltepesi.

Vegetation sampling

On each of the sampling plots vegetation data were collected. These data included number of species of medicinal plants, number of individuals and diameter at breast height (DBH) for trees and tall shrubs, height and canopy diameter for trees.

Diameter at breast height (DBH)

The circumference of the plant species was measured at 1.5 m above the ground within each quadrant using a tape measure and the measurements were later converted to diameter values using the following formula.

$D = C/\pi$ …….. (Equation 1)

Where, C=Circumference (Cm)

D=Diameter (Cm)

π=3.14

Density of the plant species

Density refers to the number of individuals of a species per unit area.

D=N/A…………(Equation 2)

Where;

D=Density

N=Total number of individuals of a species found

A=Area sampled (M^2)

Distribution Pattern of Medicinal Plants

According to Ref. [22] cited in the methods of Curtis and Cottom, the ratio of abundance to frequency (A/F) is a relative measure to present the distribution of species in a community: as A/F <0.025 (regular), between 0.025 and 0.05 (random), and >0.05 (contagious) distribution.

According to Ref. [23], abundance and frequency are calculated as follows:

Frequency (F)=(Number of quadrats in which a species occurs)/(Total number of quadrats examined) × 100 ……… (Equation 3)

Abundance (A)=(Total number of individuals found)/(Number of quadrats of occurrence) ……. (Equation 4)

Relative abundance

Relative abundance indicates the percentage of individuals within each species present in a community and how that species relates numerically to the abundance of any other species present in that community. It also reveals ecological patterns that indicate which species is dominant or least dominant on that specific site. Because of much of the calculated data in percentage contained 0, the data was log transformed to test it statistically [24].

Species diversity

Shannon diversity index [25] was used to quantify species richness and diversity within and outside the conservation area. The Shannon–Wiener index takes into account species richness and proportional abundance to calculate a single diversity measure. This is, in fact, a measure of evenness of species abundances in a sample with more even samples gaining a higher value. The Shannon diversity index (H') is calculated with the formula:

$H' = -\sum pi\ ln\ pi$ ……………………… (Equation 5)

Where:

P_i=Proportion of individuals belonging to species *i*

H'=Shannon-Wiener index

ln=Natural log (i.e., base 2.718).

Important value index

This index is calculated based on the following parameters:

Important Index Value (IV_i)=Relative density+Relative frequency+Relative dominance

Relative density=Number of stems per ha of the i^{th} species/Total number of stems per Ha of all species × 100

Relative frequency=Frequency of i^{th} species/Total frequency of all species × 100

Relative dominance=Sum basal area of i^{th} species/total basal area of all species × 10 …… (Equation 6)

RESULTS

Relative abundance of the species

The calculated relative abundance in the three research site indicated that *Balanites aegyptiaca* (36.92%) was the dominant species in KMQ, while *Commiphora africana* (28.41%) and *Balanites aegyptiaca* (27.27%) in Mile 46; and *Balanites aegyptiaca* (39.4%) was the dominant species in Oltepesi even if no significant differences were observed statistically between the sites in the relative abundance of the species (df=2, P=0.069, α=0.05).

Distribution pattern of the medicinal plants

In Mile 46 and KMQ all the species had a contagious distribution while in Oltepesi; one species *Albizia anthelmintica* had a regular distribution as it was calculated per hectare of the species (Table 2). The result showed that in the KMQ and Mile 46 sites, species had a contagious distribution while in Oltepesi; one species *Albizia anthelmintica* had a regular distribution.

Table 2: Phytosociological attributes of the species in the study areas.

Sites	Species	Phytosociological attributes		
		Frequency F (%)	**Density (Plants ha^{-1})**	**Abundance Frequency ratio**
Mile 46	*Acacia drepanolobium*	38.1	90.48	6.23
	Commiphora africana	47.62	119.05	5.25
	Commiphora schimperi	28.57	42.86	5.25
	Acacia nilotica	4.76	4.76	21.00
	Acacia tortilis	14.29	14.29	7.00
	Balanites aegyptiaca	47.62	114.29	5.04
	Salvadora persica	4.76	4.76	21.00
	Acacia mellifera	14.29	23.81	11.67
	Acacia etabica	4.76	4.76	21.00
KMQ	*Acacia mellifera*	55.00	95.00	3.14
	Balanites aegyptiaca	85.00	240	3.32
	Commiphora schimperi	65.00	95.00	2.25
	Commiphora africana	50.00	130.00	5.20
	Acacia tortilis	52.38	80.00	2.92
	Acacia etabica	10.00	10.00	10.00
Oltepesi	*Acacia tortilis*	80.00	160.00	2.50
	Balanites aegyptiaca	80.00	160.00	2.50
	Acacia mellifera	45.00	85.00	4.20
	Commiphora africana	20.00	0.25	0.06
	Acacia nubica	5.00	5.00	20
	Acacia etabica	10.00	10.00	10.00
	Commiphora schimperi	10.00	10.00	10.00
	Albizia anthelmintica	5.00	0.05	0.2
	Acacia nilotica	5.00	5.00	20.00

Species diversity

In Oltepesi research area, a lower species diversity and evenness was recorded as compared to the other two research areas, Mile 46 and Kenya Marble Quarry (KMQ) though the ANOVA test did not reveal any significant difference (df=2, P=0.259, α=0.05) between the research sites.

In Mile 46, higher species diversity was recorded as compared to KMQ and Oltepesi and KMQ had higher evenness than the other two sites (Table 3).

Table 3: Shannon-Weiner Index (H') and Evenness (H'/H_{max}) for Mile 46, KMQ and Oltepesi research sites at Kajiado County.

No.	Site	H’	Evenness
1	Mile 46	1.707	0.777
2	KMQ	1.574	0.878
3	Oltepesi	1.436	0.691

DISCUSSION

This study has provided sufficient information, quantitative and qualitative estimates regarding relative abundance, species diversity, distribution pattern and composition as well of the plant species in the research sites *Balanites aegyptiaca* (36.92%) in KMQ, *Commiphora africana* (28.41%) and *Balanites aegyptiaca* (27.27%) in Mile 46 and *Balanites aegyptiaca* (39.4%) in Oltepesi were the dominant species even if no significant differences were observed statistically. Pattern in distribution and abundance of a species in the biome is central concept in ecology providing information about species richness, species area relation, succession, the like-hood of species extinction under habitat loss, the design of reserves and the process that allows species to coexist and partition resources [26] This abundance and scarcity of species should inform what kind of conservation measures should be taken in the area. In conservation biology and management, information on relative abundances is of great importance to study the impact of habitat disturbances, such as fragmentation. It is well known that that disturbed and fragmented habitats are usually dominated by a very few species compared to the undisturbed sites [27].

Based on the study in the sites, in Mile 46 and KMQ all the species had a contagious distribution while in Oltepesi; one species *Albizia anthelmintica* had a regular distribution as it was calculated per hectare of the species. Contagious distribution is the most pervasive pattern in nature; random distribution is confined only in very uniform environments whereas regular distribution occurs in those areas where competition among several individuals exists [28]. Contagious distribution depends on the local habitat, daily and seasonal weather change and reproductive process [22]. A chance distribution of individuals indicates that all factors of the environment are at or near their optimum point for these species; the habitat may be said to be uniform. Consequently, no further investigation is necessary beyond a description of the salient features of the environment. In addition, a random distribution of an abundant species indicates that it has reached a peak importance in the community and consequently must have been present for a considerable length of time [29]. In communities below the climax level it is also an indication that the species will decline in the near future. If the species are random, then only one or a few phytosociological characters need be studied to give an adequate picture, since the others may be deduced through the use of the interrelations.

In Mile 46, higher species diversity was recorded as compared to KMQ and Oltepesi and KMQ had higher evenness than the other two sites. The species diversity in these research areas had no revealed any significant difference which implied the research sites had homogenous type of species diversity. By Ref. [30] stated that the distribution and diversity of plant species in a landscape depend on various factors (e.g., dispersal, ability, competition, environmental factors such as solar radiation, temperature and soil geological conditions) which may influence the landscape vegetation structure and would show significant effects on richness and diversity [31,32].

CONCLUSION

The medicinal plant species diversity in three sites of central Kajiado, Kajiado County in Kenya did not reported a significant difference and showed homogenous diversity. The research sites were only dominated by few medicinal plant species which would imply degradation and overutilization of the other species. This reveals that Masaai community of the area heavily relied on medicinal plants for their primary health care and medicinal plants were also used for different purposes like firewood, grazing, charcoal, fencing, construction. It is concluded that the plants were under pressure due to overall increasing demand of plant resources for various use that leads to severe threatening to medicinal plants and their conservation.

ACKNOWLEDGMENTS

Demissew Tsigemelak would like to express his gratitude to German Academic Exchange Services (DAAD) for its continuous support through Natural Product Research Network for Eastern and Central Africa (NAPRECA) for funding my study and my Supervisor Dr Najma Dharani for her financial support for my field work.

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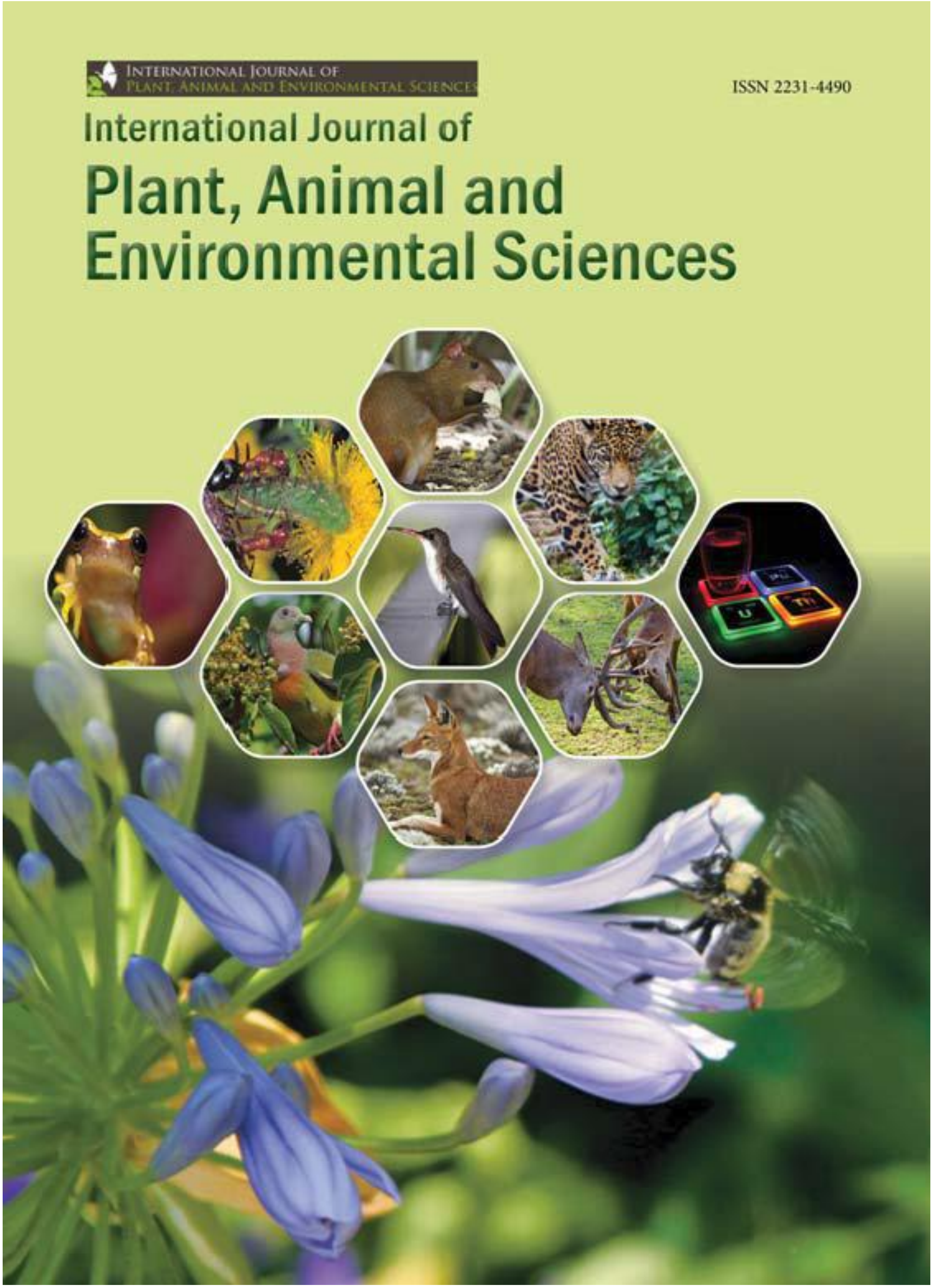
INTERNATIONAL JOURNAL OF
PLANT, ANIMAL AND ENVIRONMENTAL SCIENCES
ISSN 2231-4490
International Journal of
Plant, Animal and
Environmental Sciences