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Invasion of *Cestrum aurantiacum* Lindl. in Kenya

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Abstract

Many forest ecosystems in Kenya are at risk from the invasion of exotic plant species that pose numerous threats like decreasing biodiversity, deteriorating ecosystem processes and degrading their services. They also affect human, other animal health and various angles of the general economy. *Cestrum aurantiacum Lindl.* is a species with invasive reputation having been reported with very high biological success rating and has been noted in parts of Kenya in proportions that raise concerns. It has negative effects on other plants and animal species function and diversity. These impacts have been recorded in Kenya and elsewhere in this review, I synthesized data from studies that have examined the taxonomy of *Cestrum aurantiacum*, how this species become part of the ecosystem in Kenya and its ecological and economic impacts. I sourced relevant articles from the internet using keywords relating to the taxonomy, impacts and reports of invasive species and narrowed to records from different parts of Kenya. In this review, I looked across twenty-seven studies, on *Cestrum aurantiacum* in Kenya and went ahead to review one hundred and thirteen other articles for expanded discussion. Species data in published articles from different parts of Kenya were used as georefences to model overall species distribution which was noted to lie between Mt Kenya, Mt Elgon Nandi hills and Cherangani hills. It was clearly established that there are major adverse effects associated with species. First, it can change native ecosystem processes such as nutrient cycle or hydrology and contribute significant role on the decrease of native species. A primary risk of *Cestrum aurantiacum* is that when this species alters the biodiversity, ecosystems are transformed into new configurations with unpredictable consequences to humans and other wildlife in totality. Despite the few positive applications of *cestrum* species, these can't compensate for the enormous detrimental consequences associated with the species. *Cestrum aurantiacum* was introduced in Kenya as an ornamental plant in 1921 by the government and was distributed in several

regions of high potential Kenya. Due to high level of hybridization within the genera, several variables of the species occur. By examining the level of information regarding the taxonomy and impacts of *Cestrum aurantiacum* on animal and plant species, this study provides pivotal information at the country level with a view to informing monitoring and conservation efforts, such as alien plant removal and control programmes, and ensuring that endemic terrestrial animal and plant diversity are maintained.

Keywords

Cestrum aurantiacum Lindl, Invasive Species, Kenya, Ecosystem Impacts

1. Introduction

Non-indigenous plants constitute dominant driver of ecosystem change and a major problem for environmental management worldwide [1] [2] [3]. Majority of invasions are associated with human industry and development [4] [5] [6]. They are either deliberately or accidentally introduced [7] and pose serious threats to the biodiversity economy and human health [1] and their irreversible impact is second only to habitat loss [8] [9]. Invasive Alien Plants (IAPs), in particular, have spread rapidly and extensively in many regions of the world [10] [11] [12] [13]. In any one ecosystem, there is likely to be more than one mechanism to explain invasion success of a species and in fact, no one's hypothesis may explain invasion in totality [13]. Therefore, any effort to understand the invasive success of a species should take into account an integrative approach, which must be combined with rigorous field experiments in order to evaluate these hypotheses [14].

Beginning from the UN Summit in Rio de Janeiro in 1992, invasive species are regarded as one of the main reasons for the loss of biodiversity [15] [16] [17]. In addition, such species may alter environmental conditions and resource availability of tangible and non-tangible products from the affected ecosystem [18]. This disruption is accomplished when Invasive alien species (IES) differ from native biota in specific species traits [19]. The United Nation Environmental Programme estimates that alien invasive species cost the global economy an annual US $1.4 trillion. In East Africa, no studies have been done to quantify the cost of invasive plants species. However, studies in South Africa alone show the country spends over $60 million annually to eradicate invasive plants [20]. Nonetheless, not all invading species are equal in their ability to alter larger-scale processes. But those that dominate communities have the greatest impact [18]. The numbers of species transported across biogeographical barriers daily is presumably large but only a few become established [21] agricultural production and ornamental purposes are main reasons [22].

The era of European colonization encouraged the spread of plant exploration in quest for new species for ornamental plants for botanical gardens, nurseries

and private individuals back home some of which have escaped to become invasive [22]. When steam engine came into common use between 1820-1930, many Europeans emigrated with numerous plants and animals [22]. Also the colonial military carried many invasive species in 17th and 18th century [23]. For instance, France brought *Opuntia monacantha* and *O. ficus indica* to Madagascar in 1768 to provide barrier around fort Dauphin and feed oxen respectively [24]. Both species have colonized much of Madagascar but French colonialists have long left, leaving costs of invasion to be borne by locals. Scientists themselves are responsible for species invasions, too [25]. For example, a field scientific experiment set up to investigate salt excretion of various plants at Mission Bay (California) in the late 1960s resulted in a thriving population of the small tree *Avicennia marina* a decade later [27]. Although, the French botanist Auguste Chevalier regarded *Chromolaena odorata* as a weed and had written a paper on man's role in the dispersal of tropical plants, he nevertheless recommended its introduction to West Africa [26].

Incorporating the ecosystem services approach into conservation management is becoming increasingly prevalent through better understanding of the connections between ecosystems and their associated products and processes [27]. While much effort has gone into the quantitative valuation of these goods and services, knowledge gaps persist in understanding how invasive alien species impact ecosystem services [28]. Exotic invasive species have the capacity to alter ecosystem equilibrium [29] and to cause serious environmental problems like extirpation of native species [30] In addition, competition, predation, hybridization and several other indirect effects [31] [32] which interfere with community structure [33] and alter genetic composition [34].

Several studies have shown that invasive alien plants also have positive economic, social and ecological contributions and that these need to be considered when assessing the costs resulting from invasions [35] [36]. For instance, it is estimated that 95% of food production in the USA depends on exotic species of plants and animals [37]. It has also been recorded that invasive alien plant species can be used in agroforestry for functions and services that cannot be provided by native species [38] [39]. These services include rapid biomass accumulation, nitrogen fixation, and reforestation of degraded land, improved fallows and contour hedgerows [40]. Invasive alien plants in South Africa, have become a focal point in the conservation of indigenous plants [39]. These plants incur a tremendous cost in labor expenditure to eradicate them, a cost that a poor rurals cannot afford [40]. Kenya is rich with an enormous diversity of ecosystems and wildlife species [41]. Those are source of livelihood to Kenyans, and central to the economy thereby being indispensable to achieving the aspirations outlined in Vision 2030. There are nearly 34 invasive alien animal and plant species in Kenya [42]. In spite of its immense biotic capital, Kenya experiences severe ecological and socio-economic problems [41]. Drought negatively impacts on the country's biodiversity as well as the national economy and people's livelihoods [42]. There are also problems of human-induced environmental degradation,

such as destruction of natural landscapes, soil erosion, water pollution and loss of species [41]. Inappropriate policies and political impunity have contributed to nationwide habitat destruction, loss of species and the associated genetic resources [41]. The sustainable management of the country's biological resources is also hampered by lack of a comprehensive biodiversity policy, a biodiversity inventory and of formal procedures for benefit sharing as well as threats from invasive alien species [41]. All these play a role in proliferation of invasive species [13].

Cestrum aurantiacum Lindl. is exotic species in Kenya and native to Central America [43] [44]) and is known as an escape species from living collection and has an invasive potential in many forest areas [45]. It has been identified as a wide-spread and well established invasive species in many countries around the world [11]. *C. aurantiacum* was identified as an exotic invasive plants causing several adverse impacts including displacement of native plants from their habitat in Malawi and South Africa [46] [47]. Secondly, *C. aurantiacum* is poisonous to humans and animals [46] [48] [49] [50]. The main concern on the effect of *C. aurantiacum* as invasive species is the possible risk caused by the species invasion to forest ecosystems and economy [51]. The general understanding and theory of invasion process could be used to conceptualize the process of the invasion [52] [53]. This considers that biological invasion of an exotic species is a series of steps [54].

Available knowledge on biological invasions is geographically and taxonomically biased toward more developed regions, further complicating accurate species identification [54]. Some regions, such as Asia, South America and Africa (excluding South Africa), are inadequately studied in terms of ecology [55]. Since research intensity is generally related to economic prosperity [56] the same regions are also likely to be taxonomically understudied [57]. A typical example is found in the Usambara Mountains of Tanzania where the *Maesopsis eminii* (or Msira) tree was declared invasive and a disaster to the forest ecosystem 65 years after it was first introduced in 1913 [58]. More recently Mesquite has been declared a serious invader in Kenyan drylands twenty years after its first introduction in the early 1980s [59].

As Invasive plants continue to pose a major problem worldwide [60]. Every year, exotic species become more prevalent, extending their ranges into areas designated as nature reserves [61]. In a survey of 24 reserves worldwide, all were found to have exotic species, and some reserves harbored more exotic plant species than native species [62]. Despite these facts, invasive species have rarely been implicated as a significant threat to the conservation of tropical forests [63] and deterioration of global economies. *C. auranticum* plus five other species of cestrum have been declared category 1 noxious species in South Africa [64] [112], a Country with the highest knowledge base of invasive species in the continent [65]. Dealing with invasive plant is a challenging task that demands accurate planning and resourcing [66]. Since the last century, hundreds of exotic plants incursion have been recorded in different parts of the world. These have been of sufficient concern to warrant nationally coordinated and funded res-

ponses [67].

Many studies have proved that exotic plant invasions displace native species, disrupt ecosystem processes, and consequently inflict substantial ecological costs worldwide [1] [68] [69]. A number of exotic plant species introduced into Kenya, have escaped cultivation and now threaten biodiversity [42] [70]. Not much has been investigated about this species. *Cestrum aurantiacum* an invasive species has been cited in many parts of high potential Kenya growing in areas where not deliberately introduced. Previous Studies in New Zealand on invasive species depicted *C. aurantiacum* as a high invader basing on biological success rating [71]. *Cestrum* species are also known for their ability for rapid establishment and spread, particularly along river, roads, disturbed sites [72] and more so *Cestrum aurantiacum* has thus been also listed as potentially invasive in Sri Lanka [73].

Most of the studies addressing invasive plants have focused on their characteristics [74] [75], the process of invasion [76] [77], the effect of disturbance on invasion success [78] and the aspects of invaded systems [79]. Few studies have examined the effects of invasive species across many habitats or regions [80]. In Africa for instance, the Invasive Woody Plant Database (with over 5000 publications on species invasiveness) has only 6% referring to tropical Africa [81]. Of the few reports and studies done in East Africa, *Lantana camara* (commonly referred to as Lantana) is the most widely studied invader [70] [82]. In Kenya, there is minimal empirical data available on how *C. aurantiacum* interacts with the local habitats how was introduced and its close relatives, though it's among the most dangerous species to conserved natural ecosystems in Kenya [107].

A comprehensive analysis of existing literature may provide insight into how much we understand the impacts caused by Invasive plants on ecosystem services in forests and other lives. Such an exercise could help ecologists, social scientists, and natural resource managers to discover hidden taxes on ecosystem services and could assist in developing effective invasive species management strategies [28] [83]. Although databases accessible on the web are developing rapidly, they are still relatively data-poor in comparison with the data potentially available. Hence their value to invasive management remains limited. Moreover, the limited accessibility of online information in developing countries applies equally to online databases. Nonetheless, resources exist, such as the Global Compendium of Weeds, which contains at least some of the synonyms and common names as well as other information.

To achieve these objectives, this review seeks to fill gaps in existing knowledge on the introduction, biogeographic range and impacts of *C. aurantiacum* in Kenya. This work will contribute to the global knowledge pool on the presence and distribution of invasive cestrum species and also assist countries in meeting their obligations to various international conventions/treaties. In light of such consequences, it is important to understand the taxonomy, phytogeography and impacts of the same [66]. In this paper I examined the extent and prevalence of the impact, taxonomy and introduction of *Cestrum aurantiacum* an Invasive

species in Kenya. In view of these gaps, I reviewed the dynamic and critical role of taxonomy in the study of plant invasions and specifically examines how can be useful in understanding the phylogeny, causes of introduction and impacts of *Cestrum aurantiacum.*

2. Methodology

To accomplish this goal, I synthesized data on four targeted areas (taxonomy, introduction into Kenya, areas species has been documented and impacts of *Cestrum aurantiacum* and provided examples from the literature for extended discussion. Due to the level of hybdization possible in the genus cestrum comprehensive review of all IES requires tremendous time and effort which this review couldn't achieve. Thus I have reviewed manuscripts concerning *Cestrum aurantiacum* most detrimental IES, as identified by various local studies with little reference to the other five cestrum species from the genus declared as weeds in many parts of the world and also cited in Kenya. I conducted literature searches in journals, books, mass media, fact sheets and garden profiles, from the internet. Most of the literature cited in this review is from the USA, Australia, South Africa, Canada and New Zealand. Which are most affected by invasive and also record highest publications on the same [84]. All accessed literature on cestrum species in Kenya has been referenced. Data from species occurrence reports collected has been used as georeferences and used to model overall species distribution.

3. Results

3.1. Introduction of *Cestrum aurantiacum* in Kenya

Cestrum aurantiacum Lindl. is an exotic species [85] its native to Central America [86] [87] which has been in cultivation since 1844 when it was introduced by Englishman G.U. Skinner, who sent seeds collected in Chimalapa Guatemala to the London Horticultural Society. The species was first recorded in the official gazette general notice No. 287 of Colony and protectorate of Kenya 1921. Thereafter till 1930 several gazette notices (No. 229 and 209 of 1927 and 1928 respectively that were published and printed by his majesty's stationery office in London showing the list of tree seeds and young trees for sale in which cestrum was among the species for sale by the forest department. CPK (1927), CPK 1928. The publishing of official government documents was done in London by His Majesty's stationery.

3.2. Description of *Cestrum aurantiacum*

Cestrum aurantiacum is an evergreen, slightly scrambling shrub or small tree [88] [89]. The shrub grows to a height of up to 180 cm tall with brilliant tubular orange flowers that have a powerful citrus like smell, especially in the night [90]. These flowers have ovate, obtuse or reflexed lobes (3 - 4 mm) and are 1.4 - 2 cm in length. The leaves are 5 - 10 cm long and 4 - 6 cm wide, glabrous and ovate,

acute or acuminate in shape. The fruits are berries which are white in color and contain approximately 4 seeds. The name of the genus comes from the Greek word kestroom; which was the name of a shrub that resembled a Jasmine. The specific epithet is Latin for the color orange. This description is based on research and observations of this plant as it is depicted by consensus taxonomic opinions The Genus Cestrum (Solanaceae) with more than 300 species is globally distributed in tropical and subtropical regions throughout the world including India, southern China, Australia, USA and Bangladesh [91].

There are at least two major adverse effects of the existence of *Cestrum aurantiacum* in a native ecosystem. First, it can change native ecosystem processes such as nutrient cycle or hydrology and contribute significant role on the decrease of native species abundance [1] [30]. It was identified as an exotic invasive plants causing several adverse impact including displace native plants from their habitat in Malawi and South Africa [46] [47]. Secondly, *C. aurantiacum* is toxic to animal and possibly has similar effect on human [46] [48] (**Figure 1**).

4. Discussions

The earliest records of Cestrum introduction in Kenya dates back to 1921 (see **Table 1**), the Colony and protectorate of Kenya government which was under His Majesty of Britain had its nerve centre of operations in London. For instance the publishing of official government documents for Kenya colony and protectorate was done in London by His Majesty's stationery Implies that there was a lot of communication between London and Nairobi. Also, the shortest route from London to Nairobi was through the Suez Canal. Almost immediately after its opening, the Suez Canal had a significant impact on world trade as goods were moved around the world in record time. In 1875, debts forced Egypt to sell its shares in ownership of the Suez Canal to the United Kingdom. However, an international convention in 1888 made the canal available for all ships

Table 1. Biogeographical range of cestrum invasion in Kenya.

	Date	SPP	GNO	Vol.	No	Pg.	Description	Price
1	9/3/1921	*C. aurantiacum*	287	23	761	206	Ornamental shrub	11/100 8/pd
2	9/3/1927	*C. aurantiacum*	229	29	1131	290	Ornamental shrub with yellow leaves& white berries	
3	25/10/1927	*C. aurantiacum*	-	29	1169	1288	Ornamental shrub with yellow leaves & white berries	20 cts
4	6/3/1928	*C. aurantiacum*	209	30	13	19	Ornamental shrub with yellow flowers	
5	19/2/1929	*diurnum*	-	31	12	358	Ornamental shrub with white flowers	
6	17/9/1929	*diurnum*	-	1248	31	49	1985	10 cts

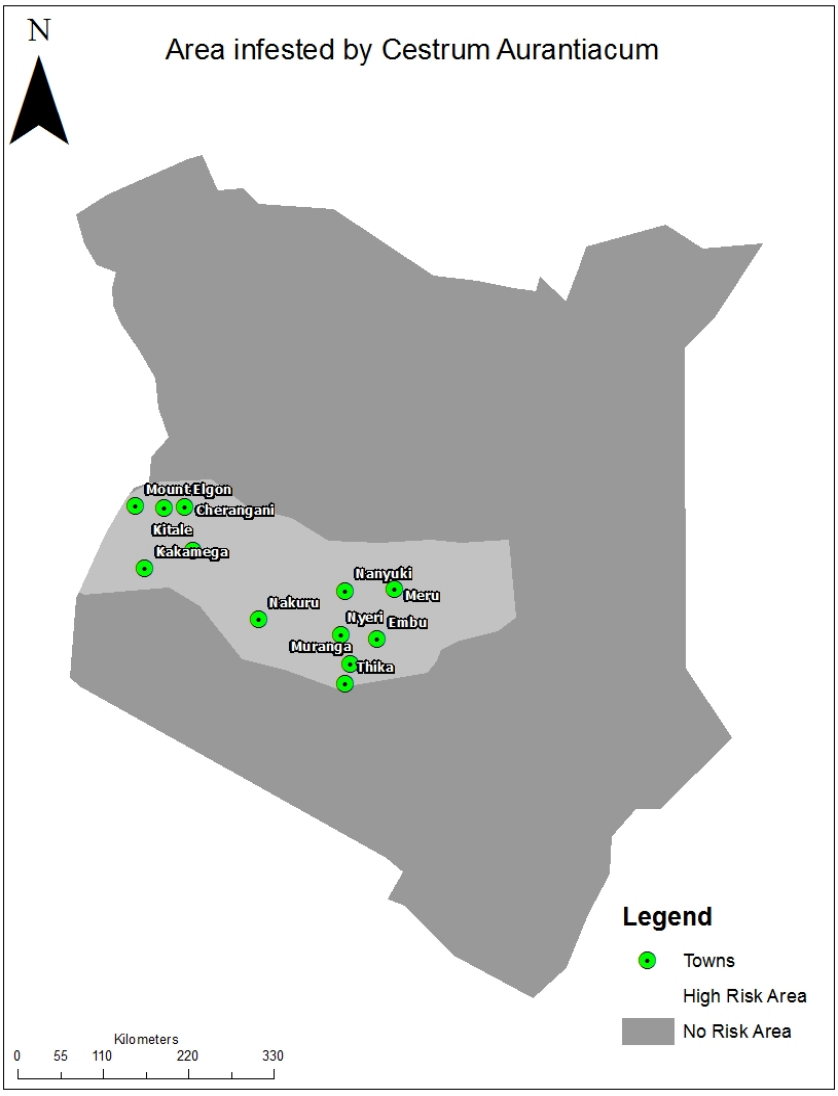

Figure 1. Introduction of cestrum in Kenya Regions of Kenya in which *Cestrum aurantiacum* has been reported.

from any nation to use. But from the annual reports of the Colony and protectorate of Kenya 192, 1930, visits by his majesty from London to Kenya started from Mombasa. Therefore, it's most likely that the pathway of cestrum was through Suez Canal to Mombasa via medterrenean sea. There are several species of the genus *Cestrum*. However, in the field, speciation within the genus is often uncertain due to hybridization [112].

Forty publications reviewed on the impacts of *Cestrum aurantiacum* in Kenya gave 19 with beneficial impacts to nature with 21 having negative effects (**Table 4**). 14 reports were about livestock poisoning and 7 on ecological destabilization. Medicinal use is the most widely reported beneficial application of *Cestrum aurantiacum* (See **Table 2** & **Table 3**). A phytochemical screening of *Cestrum* Species (*C. aurantiacum*, *C. diurnum* and *C. purpureum)* revealed the presence of steroidal saponins, sterols, catechol tannins, carbohydrates and flavonoids.

Table 2. List of seedling and seeds of cestrum species for sale by the colony & protectorate of Kenya Forest Department.

	Impact	Place	Authority	cause
1	Dog poisoning	Rhodesia		*Parqui*
2	Livestock death	South wales	[92]	*C. aurantiacum*
3	Displace native spp & serious invader of native ecosystems	Zambia	[44]	*C. aurantiacum*
4	Livestock	New S. wales	[92]	*C. aurantiacum*
5	Interfere with ecosystem of montane forests		[51]	*C. aurantiacum*
6	Cattle poisoning	Australia	[48]	*Parqui*
7	Hepatoxicity in livestock	USA		*diurnum*
8	Livestock Hepatoxicity	USA		*C. aurantiacum*
9	Use the vegetation as cover to pounce on innocent victims	South Africa		*C. aurantiacum*

Table 3. Positive impacts of *cestrum aurantiacum.*

Impact	Place	Authority	Species
Food for insect *Rhodogastria amasis*			*C. aurantiacum*
Ornamental	N & America	[81]	*C. aurantiacum*
Medium risk invasive	India-Kerala	[81]	
Antioxidant, anti-hyperlipidemic, hepatoprotective, analgesic, antibacterial, antifungal, anti-convulsant, and larvicidal activities.	India, Bangalore	[93] [94]	*C.noctornum*
Food for larvae		[95]	*C. aurantiacum*
Caterpillar food		[96]	
Food and shelter for some birds		[97]	*C. aurantiacum*
Food for birds	India	[98]	*C. aurantiacum*
Aid in Divination	Brazil (wajacas)	[99]	*Laevigatum*
Piscidal activity		[100]	*Cestrum spp.*
Insecticidal activity	Sri-lanka	[101]	*C. aurantiacum*
Essential oils. anti-microbial, anti-cancer, antihehelminthic, anti-insect, antiviral	India. Gorokhpar University	[102]	*C. aurantiacum*
Bio-insecticide	Sri Lanka	[101]	*C. aurantiacum*
Anti-microbial	India	[49]	*C. aurantiacum*
Anti-oxidant and anti-microbial activity	India	[94]	*C. aurantiacum*

Sucrose, glucose and fructose were the only sugars detectable in the three species. The unsaponifiable matters of lipids of the three species were found to contain β-amyrin and β-sitosterol. The fatty acids were identified as myristic, palmitic,

Table 4. Negative impacts of *Cestrum aurantiacum.*

	Impact	Place	Authority
1	Livestock poisoning	Kenya	[103]
2	Affect Ecosystem	Nandi forests	[104]
3	Goats	Cherangani forest	
4	Affect Ecosystem	Cherangani forests	[104]
5	Affect ecosystem	Hells gate Olkaria	
6	Colt poisoning	Tigoni Limuru	[105]
	Affect ecosystem	Cherangani forest	
7	Affect ecosystem	Mt. Kenya	[106]
8	Affect ecosystem	Cherangani Forest	[107]
9	Affect ecosystem	Mt Elgon Kenya	[107]
10	Bee forage	Kiambu	[108]
11	Noxious weed	Cherangani	[109]
12	Noxious weed	Kakamega	
13	Noxious weed	Nairobi	[110]
14	Affect Ecosystem	Cherangani	
15	Livestock	South rift	
16	Man & vertebrates	Kitale	
17	Cattle	Limuru	
18	Noxious weed	Cherangani	[111]
19	Sheep	Nairobi	

stearic, oleic and linoleic. The percentage of these acids in the different species revealed quantitative differences [113]. These compounds are responsible for the medicinal applications of these species (See **Table 2**).

A remarkably case of *cestrum aurantiacum* poisoning in Kenya was during March 1950, death in stock of unknown etiology was reported from a farm in Limuru District. Following an investigation by [114], the cause of death was found to be *Cestrum aurantiacum* poisoning. Cestrum poisoning was reported for the first time in Kenya in 1948 it therefore, became the intention of the government to schedule it as noxious weed in those districts where conditions allow for its rapid multiplication and it had escaped from cultivation and spread into grazing areas [110]. Another case was when a two and a half year old colt from Tigoni Limuru was admitted at the large animal clinic department of veterinary studies university of Nairobi on 13/6/1990 [105] it had rather protracted history, the owner admitted it fed on cestrum cut from nearby hedge [113]. These cases highlight the significance of understanding the consequences of having cestrum in our living environment.

Cestrum aurantiacum has been reported adversely in Montane forests, in Sri

Lanka [5] and is a major invasive alien plants that was imported intentionally through the Royal Botanic Garden at Peradeniya [115]. Among these, human intervention has facilitated the spread of several invasive plant species within the country in Kenya it's also cited in montane forests like Cherangani [111] and Mount Kenya [106]. The species is a high potential species considering that studies by [70] reported on key invasive species of dry tropical forests of Kenya and Tanzania never listed it. *C. aurantiacum* has been identified as an exotic invasive plants causing several adverse impact including displacement of native plants from their habitat in Malawi and South Africa [46] [47]. Subsequently, *C. aurantiacum* is toxic to animal and possibly has similar effect on human [46] [48].

According to [116] the use of cestr*um aurantiacum* as an antimicrobial agent was new. The active principle behind this could be alkaloid or saponins, but to prove this, more study has to be conducted. In a study conducted by [49] to identify insecticidal plants of potential value in Sri Lanka, *C. aurantiacum* recorded very high mortality [101] (See **Table 3**). Also *C. aurantiacum* showed stronger antibacterial activity compared to other species and acetone extract of it produced maximum zone of inhibition (18 mm) against K. pneumonia. In case of fungi, the zones of inhibition were highest (16 mm) for butanol extract of *C. nocturnum* against Aspergillus. Whereas, ethanol extract of *C. diurnum* showed maximum zone of inhibition (14 mm) against Trichoderma in Bangalore india [94].

Several beneficial uses of cestrum species have also been documented (see **Table 3**). The flowers of *Cestrum aurantiacum* are visited by the bees in the absence of coffee flowers in Kiambu Kenya [108]. In the United States of America it's cultivated as ornamental [81] and Kenya (C & PK 1921; 1929). *Cestrum* species are used as food by caterpillars of several Lepidoptera species [117] and the insect *Rhodogastria amasis.* It is either known or suspected that such Lepidoptera are able to sequester the toxins from the plant, *Cestrum* species are reported as pesticidal [100]. *C. laevigatum* is employed by *wajacas* of the Krahós, Krahô tribe in Brazil. It is used "to see far", *i.e.* to aid in divination. Like the other hallucinogenic plants consumed by them, *Craós wajacas* consider it a potent entheogen [118]. Medicinal application of *Cestrum nocturnum* has been widely documented by amrita 2016. In Western Cape Province, where poor households in townships and informal settlements are dependent on wood collected from invading *Acacia longifolia* for construction poles and firewood for cooking and heating [5]. It is clear that in South Africa invasive plants are part of their landscape and their existence is hardly frowned upon, they are commercially exploited and in most communities where they occur they are welcomed [1].

Although cestrum species appear to arrive back in 1921 in Kenya [119]. The first report of cestrum poisoning was by the Veterinary department (1948) in the annual report of 1948 about sheep poisoning (See **Table 1**). Further reports were from Limuru [103] [120]. In countries with large populations of livestock like Brazil knowledge base of plant poisoning increased rapidly in the last decade.

Data from the Brazil indicate that, on average, 10% - 14% of cattle deaths investigated by laboratories involve plant poisoning, and if this is extrapolated to the rest of the country, between 800,000 and 1,120,000 cattle are lost to plant poisoning every year [121]. Southern Africa on the other hand has about 600 species of plants known to cause poisoning of livestock, and the total cost of plant poisoning and mycotoxicoses to the livestock industry in South Africa was estimated at ZAR 150 million [122]. The expected annual losses due to plant poisoning of domestic ruminants in South Africa in 1996 were 37,665 cattle (10% of expected cattle deaths) and 264,851 small stock per year [122]. Although plant poisoning of livestock is reported to be important in Brazil, it appears to involve fewer plants than have been reported in South Africa possibly because, plant intoxication is under-reported, as many of the poisonings described by [123].

All parts of *Cestrum* species are toxic to mammals [125]. Inkberry and Chilean inkberry are extremely harmful to cattle. If large quantities are eaten the animal usually dies immediately. Orange cestrum is often the cause of poisoning in Zimbabwe and East Africa [123] Night-blooming cestrum, *C. nocturnum*, can cause respiratory problems from the scent and feverish symptoms following ingestion. *C. aurantiacum* [124] [125] and C. parqui [48] [126] are also primarily hepatotoxic and neurotoxicity. Another peculiar neurotoxicity that has been described in Brazil and South Africa is *Prosopis* poisoning. Cattle and goats are poisoned when large quantities of the pods of the highly invasive *Prosopis juliflora* are ingested [123] *Lantana* poisoning appears to be less frequent, and only a few cases of diplodiosis has been recorded in Brazil [51] and several in Kenya [70]. According to [118], plant poisoning is one of the leading causes of death in farm animals, the other two being: rabies, transmitted by vampire bats, and epidemic botulism, which is predisposed by phosphate deficiency. parqui (inkberry) is species also cited in Kenya considered to be a potential ecosystem transformer [64].

Today planting of some Cestrum species is still promoted in some parts of Kenya (See **Table 3**). This is against background understanding that People with respiratory sensitivities or asthma, have reported difficulty in breathing, irritation of the nose and throat, headache, nausea, or other symptoms when exposed to the blossom's powerful scent [127]. Some species of *Cestrum* contain chlorogenic acid, and the presence of this potent sensitizer is responsible for this effect in *C. nocturnum.* Ingesting plant parts especially fruit results in elevated temperature, rapid pulse, excess salivation, gastritis, hallucinations, nervous irritability, tachycardia and paralysis [128] and while a non-fatal poisoning of a human child was reported by [129]. Just like *Cestrum aurantiacum*, *Cestrum nocturnum* is known to aggressively colonize disturbed areas [130] and is capable of forming dense impenetrable thickets in the undergrowth of some forest systems [130] displacing other species of plants and altering natural ecological processes. It has been shown suitable for capturing and using light than native Hawaiian species in greenhouse conditions. Like all *Cestrum* species, all parts of *C. noc-*

turnum are known to be highly toxic either fresh or when dried [129].

5. Conclusions and Recommendations

Cestrum is taxa of 246 species, 6 of which have been reported in Kenya. Members have high level of hybridization complicating discrete delimitation of species. *Cestrum aurantiacum* and *diurnum* were introduced in Kenya by the government in 1921 and 1929 respectively. The following parts of Kenya have reports of cestrum invasion, Nairobi, Limuru, Kiambu, Mt kenya region, Cherangani forest ecosystem, Nandi forest, Trans Nzoia, Mt Elgon, Kericho and Kakamega. *Cestrum aurantiacum* and *cestrum* as taxa are generally highly invasive and toxic to humans and livestock and interfere with stability of natural ecosystems. And it has been discouraged for planting in many parts the world and Kenya. A feasibility study on how to use *C. aurantiacum* for producing bio-insecticide and other applications should be initiated. Harvesting can be implemented like gradual harvesting until all propagules are eradicated.

A review on management of cestrum species needs to be done.

References

[1] Mack, R.N., Simberloff, D., Lonsdale, W.M., Evans, H., *et al.* (2000) Biotic Invasions: Causes, Epidemiology, Global Consequences, and Control. *Ecological Applications*, **10**, 689-710. https://doi.org/10.1890/1051-0761(2000)010[0689:BICEGC]2.0.CO;2

[2] Parker, I.M., Simberloff, D., Lonsdale, W.M., *et al.* (1999) Impact: Toward a Framework for Understanding the Ecological Effects of Invaders. *Biological Invasions*, **1**, 3-19. https://doi.org/10.1023/A:1010034312781

[3] Chambers, J.C., Roundy, B.A., Blank, R.R., *et al.* (2007) What Makes Great Basin Sagebrush Ecosystems Invasible by *Bromus tectorum*? *Ecological Monographs*, **77**, 117-145. https://doi.org/10.1890/05-1991

[4] Mooney, H.A. and Hobbs, R.J. (2000) Invasive Species in a Changing World.

[5] McNeely, J.A. (2001) The Great Reshuffling: Human Dimensions of Invasive Alien Species. IUCN.

[6] Ruiz, G.M. and Carlton, J.T. (2003) Invasion Vectors: A Conceptual Framework for Management. Invasive Species: Vectors and Management Strategies, 459-504.

[7] Byers, J.E. (2002) Impact of non-Indigenous Species on Natives Enhanced by Anthropogenic Alteration of Selection Regimes. *Oikos*, **97**, 449-458. https://doi.org/10.1034/j.1600-0706.2002.970316.x

[8] Warunasinghe, W.A.A.I. (2015) Awareness and Distribution of Invasive Alien Species (ias) of Flora in Galigamuwa Area. Proceedings of the Peradeniya University International Research Sessions, Sri Lanka, 5-6 November 2015, Vol. 19.

[9] Butchart, S.H., Walpole, M., Collen, B., van Strien, A., *et al.* (2010) Global Biodiversity: Indicators of Recent Declines. *Science*, **328**, 1164-1168. https://doi.org/10.1126/science.1187512

[10] Levine, J.M., Vilà, M., Antonio, C.M.D., *et al.* (2003) Mechanisms Underlying the Impacts of Exotic Plant Invasions. *Proceedings of the Royal Society of London B: Biological Sciences*, **270**, 775-781. https://doi.org/10.1098/rspb.2003.2327

[11] Pyšek, P., Jarošík, V., Hulme, P.E., *et al.* (2012) A Global Assessment of Invasive

Plant Impacts on Resident Species, Communities and Ecosystems: The Interaction of Impact Measures, Invading Species' Traits and Environment. *Global Change Biology*, **18**, 1725-1737. https://doi.org/10.1111/j.1365-2486.2011.02636.x

[12] Schirmel, J., Bundschuh, M., Entling, M.M., *et al.* (2016) Impacts of Invasive Plants on Resident Animals across Ecosystems, Taxa, and Feeding Types: A Global Assessment. *Global Change Biology*, **22**, 594-603. https://doi.org/10.1111/gcb.13093

[13] Vilà, M., Espinar, J.J., Hejda, M., *et al.* (2011) Ecological Impacts of Invasive Alien Plants: A Meta-Analysis of Their Effects on Species, Communities and Ecosystems. *Ecology Letters*, **14**, 702-708. https://doi.org/10.1111/j.1461-0248.2011.01628.x

[14] Blumenthal, D.M. and Hufbauer, R.A. (2007) Increased Plant Size in Exotic Populations: a Common-Garden Test with 14 Invasive Species. *Ecology*, **88**, 2758-2765. https://doi.org/10.1890/06-2115.1

[15] Keane, R.M. and Crawley, M.J. (2002) Exotic Plant Invasions and the Enemy Release Hypothesis. *Trends in Ecology & Evolution*, **17**, 164-170. https://doi.org/10.1016/S0169-5347(02)02499-0

[16] Collier, M.H., Vankat, J.L. and Hughes, M.R. (2002) Diminished Plant Richness and Abundance below *Lonicera maackii*, an Invasive Shrub. *The American Midland Naturalist*, **147**, 60-71. https://doi.org/10.1674/0003-0031(2002)147[0060:DPRAAB]2.0.CO;2

[17] Huebner, C.D. (2003) Vulnerability of Oak-Dominated Forests in West Virginia to Invasive Exotic Plants: Temporal and Spatial Patterns of Nine Exotic Species Using Herbarium Records and Land Classification Data. *Castanea*, **68**, 1-14.

[18] Gordon, D.R. (1998) Effects of Invasive, Non-Indigenous Plant Species on Ecosystem Processes: Lessons from Florida. *Ecological Applications*, **8**, 975-989. https://doi.org/10.1890/1051-0761(1998)008[0975:EOINIP]2.0.CO;2

[19] Ehrenfeld, J.G. (2003) Effects of Exotic Plant Invasions on Soil Nutrient Cycling Processes. *Ecosystems*, **6**, 503-523. https://doi.org/10.1007/s10021-002-0151-3

[20] Enviro-Conserve (2010) Alarming Decline in Biodiversity: Invasive Species a Threat to World Biodiversity and the Global Economy.

[21] Mooney, H.A. and Cleland, E.E. (2001) The Evolutionary Impact of Invasive Species. *Proceedings of the National Academy of Sciences of the United States of America*, **98**, 5446-5451. https://doi.org/10.1073/pnas.091093398

[22] Reichard, S.H. and White, P. (2001) Horticulture as a Pathway of Invasive Plant Introductions in the United States: Most Invasive Plants Have Been Introduced for Horticultural Use by Nurseries, Botanical Gardens, and Individuals. *BioScience*, **51**, 103-113. https://doi.org/10.1641/0006-3568(2001)051[0103:HAAPOI]2.0.CO;2

[23] Binggeli, P. (1996) A Taxonomic, Biogeographical and Ecological Overview of Invasive Woody Plants. *Journal of Vegetation Science*, **7**, 121-124. https://doi.org/10.2307/3236424

[24] Marambe, B., Bambaradeniya, C., Pushpa Kumara, D.K. and Pallewatta, N. (2001) Human Dimensions of Invasive Alien Species in Sri Lanka. In: McNeely, J.F., Ed., *The Great Reshuffling-Human Dimensions of Invasive Alien Species*, IUCN, Gland, Switzerland and Cambridge, UK, 135-142.

[25] Moran, R. (1980) Did You Say Mangroves? In Mission Bay? *Environment Southwest*, **488**, 10-13.

[26] Chevalier, A. (1931) Le rôle de l'Homme dans la dispersion des plantes tropicales. Échanges d'espèces entre l'Afrique Tropicale et l'Amérique du Sud. *Revue de Botanique Appliquée et d' Agriculture Coloniale*, **11**, 633-650.

https://doi.org/10.3406/jatba.1931.5016

[27] Patterson, T.M. and Coelho, D.L. (2009) Ecosystem Services: Foundations, Opportunities, and Challenges for the Forest Products Sector. *Forest Ecology and Management*, **257**, 1637-1646. https://doi.org/10.1016/j.foreco.2008.11.010

[28] Pejchar, L. and Mooney, H.A. (2009) Invasive Species, Ecosystem Services and Human Well-Being. *Trends in Ecology & Evolution*, **24**, 497-504.

[29] Ehrenfeld, J.G. (2010) Ecosystem Consequences of Biological Invasions. *Annual Review of Ecology, Evolution, and Systematics*, **41**, 59-80. https://doi.org/10.1146/annurev-ecolsys-102209-144650

[30] Gurevitch, J. and Padilla, D.K. (2004) Are Invasive Species a Major Cause of Extinctions? *Trends in Ecology & Evolution*, **19**, 470-474. https://doi.org/10.1016/j.tree.2004.07.005

[31] Blackburn, T.M., Cassey, P., Duncan, R.P., Evans, K.L. and Gaston, K.J. (2004) Avian Extinction and Mammalian Introductions on Oceanic Islands. *Science*, **305**, 1955-1958. https://doi.org/10.1126/science.1101617

[32] Gaertner, M., Den Breeyen, A., Hui, C. and Richardson, D.M. (2009) Impacts of Alien Plant Invasions on Species Richness in Mediterranean-Type Ecosystems: A Meta-Analysis. *Progress in Physical Geography: Earth and Environment*, **33**, 319-338. https://doi.org/10.1177/0309133309341607

[33] Hejda, M., Pyšek, P. and Jarošík, V. (2009) Impact of Invasive Plants on the Species Richness, Diversity and Composition of Invaded Communities. *Journal of Ecology*, **97**, 393-403. https://doi.org/10.1111/j.1365-2745.2009.01480.x

[34] Ellstrand, N.C. and Schierenbeck, K.A. (2000) Hybridization as a Stimulus for the Evolution of Invasiveness in Plants? *Proceedings of the National Academy of Sciences of the United States of America*, **97**, 7043-7050. https://doi.org/10.1073/pnas.97.13.7043

[35] Nyongesa (2015) Cestrum Field Day in KEFRI. Newsletter Issue No. 1, 5 Oct-Dec. 2015, Kenya Forestry Research Institute.

[36] Zhang, C. and Boyle, K.J. (2010) The Effect of an Aquatic Invasive Species (*Eurasian watermilfoil*) on Lakefront Property Values. *Ecological Economics*, **70**, 394-404. https://doi.org/10.1016/j.ecolecon.2010.09.011

[37] Pimentel, D., Lach, L., Zuniga, R. and Morrison, D. (2000) Environmental and Economic Costs of Nonindigenous Species in the United States. *BioScience*, **50**, 53-65. https://doi.org/10.1641/0006-3568(2000)050[0053:EAECON]2.3.CO;2

[38] Le Maitre, D.C., Versfeld, D. and Chapman, R.A. (2000) The Impact of Invading Alien Plants on Surface Water Resources in South Africa: A Preliminary Assessment. *Water SA*, **26**, 397-408.

[39] Richardson, D.M. and Van Wilgen, B.W. (2004) Invasive Alien Plants in South Africa: How Well Do We Understand the Ecological Impacts? Working for Water. *South African Journal of Science*, **100**, 45-52.

[40] Crooks, G.E. (2000) Path-Ensemble Averages in Systems Driven Far from Equilibrium. *Physical Review E*, **61**, 2361. https://doi.org/10.1103/PhysRevE.61.2361

[41] MOPND (2010) Millennium Development Goals Progress Report for Kenya, 2010.

[42] Kedera, C. and Kuria, B. (2005) Invasive Alien Species in Kenya: Status and Management. *Proceedings of a Workshop*, Braunschweig, Germany, 22-26 September 2003.

[43] Fischer, E., *et al.* (2010) Annotated Checklist of the Vascular Plants of Kakamega Forest, Western Province, Kenya. *Journal of East African Natural History*, **99**, 129-226.

https://doi.org/10.2982/028.099.0205

[44] Neville, G.W.H., Murphy, S.J. and Preston, G. (2003) Invasive Alien Species in Southern Africa. Lusaka, Zambia.

[45] Monro, A.K. (2012) Eight New Species of *Cestrum* (Solanaceae) from Mesoamerica. *PhytoKeys*, **8**, 49-82. https://doi.org/10.3897/phytokeys.8.2238

[46] Macdonald, I., *et al.* (2003) Invasive Alien Species in Southern Africa: National Reports and Directory of Resources. Global Invasive Species Programme, Cape Town.

[47] Henderson, L. (2007) Invasive, Naturalized and Casual Alien Plants in Southern Africa: A Summary Based on the Southern African Plant Invaders Atlas (SAPIA). *Bothalia*, **37**, a322. https://doi.org/10.4102/abc.v37i2.322

[48] McLennan, M. and Kelly, W. (1984) *Cestrum parqui* (Green Cestrum) Poisoning in Cattle. *Australian Veterinary Journal*, **61**, 289-291.

[49] Sivaraj, B., Vidya, C., Nandini, S. and Sanil, R. (2015) Antimicrobial Activity of *Cestrum aurantiacum* L. *International Journal of Current Microbiology and Applied Sciences*, **4**, 830-834.

[50] Maroyi, A. (2012) Garden Plants in Zimbabwe: Their Ethnomedicinal Uses and Reported Toxicity. *Ethnobotany Research and Applications*, **10**, 45-57. https://doi.org/10.17348/era.10.0.045-057

[51] Junaedi, D.I. (2012) Invasive Plants in Mountainous Remnant Forest: Recommendation for Choosing Best Decision for Invasive Species Management of *Cestrum aurantiacum* Lindl. *Buletin Kebun Raya*, **15**, 36-45.

[52] Richardson, D.M., *et al.* (2000) Naturalization and Invasion of Alien Plants: Concepts and Definitions. *Diversity and Distributions*, **6**, 93-107.

[53] Theoharides, K.A. and J.S. Dukes (2007) Plant Invasion across Space and Time: Factors Affecting Nonindigenous Species Success during Four Stages of Invasion. *New Phytologist*, **176**, 256-273.

[54] Geldenhuys, C.J. (2004) Concepts and Process to Control Invader Plants in and around Natural Evergreen Forest in South Africa. *Weed Technology*, **18**, 1386-1391.

[55] Pyšek, P., Lambdon, P.W., Arianoutsou, M., Kühn, I., Pino, J. and Winter, M. (2009) Alien Vascular Plants of Europe. In: *Handbook of Alien Species in Europe*, Springer, Berlin, 43-61. https://doi.org/10.1007/978-1-4020-8280-1_4

[56] Leimu, R. and Koricheva, J. (2005) What Determines the Citation Frequency of Ecological Papers? *Trends in Ecology & Evolution*, **20**, 28-32.

[57] Stuessy, T.F. and Lack, H.W. (2011) Monographic Plant Systematics. Fundamental Assessment of Plant Biodiversity. Koeltz, Königstein. [Regnum Veg. 153].

[58] Hamilton, A. (1998) Vegetation, Climate and Soil: Altitudinal Relationships on the East Usambara Mountains, Tanzania. *Journal of East African Natural History*, **87**, 85-89. https://doi.org/10.2982/0012-8317(1998)87[85:VCASAR]2.0.CO;2

[59] Pasiecznik, N.M., *et al.* (2006) Discovery of a Life History Shift: Precocious Flowering in an Introduced Population of *Prosopis*. *Biological Invasions*, **8**, 1681-1687. https://doi.org/10.1007/s10530-005-5106-0

[60] Global Invasive Species Database (2005) Invasive Species Found in Kenya. http://www.issg.org/database/species/ecology.asp?si=19&fr=1&sts=sss

[61] Amezaga, J., Santamaría, L. and Green, A.J. (2002) Biotic Wetland Connectivity—Supporting a New Approach for Wetland Policy. *Acta Oecologica*, **23**, 213-222. https://doi.org/10.1016/S1146-609X(02)01152-9

[62] Usher, M.B. (1988) Biological Invasions of Nature Reserves: A Search for Generali-

sations. *Biological Conservation*, **44**, 119-135. https://doi.org/10.1016/0006-3207(88)90007-9

[63] Fine, P.V. (2002) The Invasibility of Tropical Forests by Exotic Plants. *Journal of Tropical Ecology*, **18**, 687-705. https://doi.org/10.1017/S0266467402002456

[64] Henderson, L. (2001) Alien Weeds and Invasive Plants. In: *Plant Protection Research Institute Handbook*, Pretoria, South Africa.

[65] McNeely, J.A. (2006) As the World Gets Smaller, the Chances of Invasion Grow. *Euphytica*, **148**, 5-15. https://doi.org/10.1007/s10681-006-5937-5

[66] Williamson, M. (1999) Invasions. *Ecography*, **22**, 5-12.

[67] Cox, G.W. (1999) Alien Species in North America and Hawaii. Island Press, Washington DC.

[68] Pimentel, D., Zuniga, R. and Morrison, D. (2005) Update on the Environmental and Economic Costs Associated with Alien-Invasive Species in the United States. *Ecological Economics*, **52**, 273-288. https://doi.org/10.1016/j.ecolecon.2004.10.002

[69] Vitousek, P.M., D'antonio, C.M., Loope, L.L., Rejmanek, M. and Westbrooks, R. (1997) Introduced Species: A Significant Component of Human-Caused Global Change. *New Zealand Journal of Ecology*, **21**, 1-16.

[70] Obiri, J.F. (2011) Invasive Plant Species and Their Disaster-Effects in Dry Tropical Forests and Rangelands of Kenya and Tanzania. *Jàmbá*: *Journal of Disaster Risk Studies*, **3**, 417-428. https://doi.org/10.4102/jamba.v3i2.39

[71] Froude, V. (2002) Biological Control Options for Invasive Weeds of New Zealand Protected Areas. Department of Conservation, Wellington.

[72] Wijesundara, S., Weerakoon, D. and Wijesundara, S. (2012) Present Status of Montane Forests in Sri Lanka. In: *The National Red List* 2012 *of Sri Lanka*: *Conservation status of the Fauna and Flora*.

[73] Ranwala, S., *et al.* (2011) Post-Entry Risk Assessment of Invasive Alien Flora in Sri Lanka-Present Status, GAP Analysis, and the Most Troublesome Alien Invaders. *Pakistan Journal of Weed Science Research*, **18**, 863-871.

[74] Noble, I.R. (1989) Attributes of Invaders and the Invading Process: Terrestrial and Vascular Plants. In: Drake, J.A., Mooney, H.A., di Castri, F., *et al.*, Biological Invasions: A Global Perspective, Wiley, New York, 301-313.

[75] Reichard, S.H. and Hamilton, C.W. (1997) Predicting Invasions of Woody Plants Introduced into North America. *Conservation Biology*, **11**, 193-203.

[76] D'Antonio, C., Levine, J. and Thomsen, M. (2001) Ecosystem Resistance to Invasion and the Role of Propagule Supply: A California Perspective. *Journal of Mediterranean Ecology*, **2**, 233-246.

[77] Rejmánek, M. and Richardson, D.M. (1996) What Attributes Make Some Plant Species More Invasive? *Ecology*, **77**, 1655-1661.

[78] Hobbs, R.J. and Huenneke, L.F. (1992) Disturbance, Diversity, and Invasion: Implications for Conservation. *Conservation Biology*, **6**, 324-337.

[79] Stohlgren, T.J. (2002) Beyond Theories of Plant Invasions: Lessons from Natural Landscapes. *Comments on Theoretical Biology*, **7**, 355-379.

[80] Alvarez, M.E. and Cushman, J. (2002) Community-Level Consequences of a Plant Invasion: Effects on Three Habitats in Coastal California. *Ecological Applications*, **12**, 1434-1444.

[81] Thapa, G.J., *et al.* (2014) *Proceedings of the International Conference on Invasive Alien Species Management*.

[82] Simba, Y.R., Kamweya, A.M., Mwangi, P.N. and Ochora, J.M. (2013) Impact of the Exotic Weed, *Lantana camara* L. on Abundance of Native Plants in Nairobi National Park, Kenya: Implications for the Conservation of Wildlife. *International Journal of Science and Research*, **2**, 294-300.

[83] Webster, C.R., Jenkins, M.A. and Jose, S. (2006) Woody Invaders and the Challenges They Pose to Forest Ecosystems in the Eastern United States. *Journal of Forestry*, **104**, 366-374.

[84] Den Breeÿen, A. and Charudattan, R. (2009) Biological Control of Invasive Weeds in Forests and Natural Areas by Using Microbial Agents. In: Inderjit, Eds., *Management of Invasive Weeds*, Springer, Dordrecht, 189-209. https://doi.org/10.1007/978-1-4020-9202-2_10

[85] Rambuda, T.D. and Johnson, S.D. (2004) Breeding Systems of Invasive Alien Plants in South Africa: Does Baker's Rule Apply? *Diversity and Distributions*, **10**, 409-416.

[86] Yun, Z.B., *et al.* (1994) Serum Hepatitis C Virus RNA Levels in Chronic Hepatitis C-Importance for Outcome of Interferon Alfa-2b Treatment. *Scandinavian Journal of Infectious Diseases*, **26**, 263-270.

[87] de Rojas, C.B. and D'Arcy, W.G. (1998) The Genera Cestrum and Sessea (Solanaceae: Cestreae) in Venezuela. *Annals of the Missouri Botanical Garden*, **85**, 273-351. https://doi.org/10.2307/2992010

[88] Ironwood, C. UC Riverside Botanic Gardens Spring Plant Sale.

[89] Cameron, L.P. (2005) The Secret Gardens of Charleston. Gibbs Smith, Layton.

[90] Berg, C. and Greilhuber, J. (1993) Cold-Sensitive Chromosome Regions and Heterochromatin in *Cestrum aurantiacum* (*Solanaceae*). *Plant Systematics and Evolution*, **185**, 259-273. https://doi.org/10.1007/BF00937662

[91] Al-Reza, S.M., Rahman, A. and Kang, S.C. (2009) Chemical Composition and Inhibitory Effect of Essential Oil and Organic Extracts of *Cestrum nocturnum* L. on Food-Borne Pathogens. *International Journal of Food Science & Technology*, **44**, 1176-1182. https://doi.org/10.1111/j.1365-2621.2009.01939.x

[92] Edgar, G. (1933) "Orange Bush" Proved Poisonous to Stock. *Agricultural Gazette of New South Wales*, **44**.

[93] Shaista, A. and Amrita, P. (2016) Delicate, Fragrant, Lady of the Night—A Medicinal Gift. *Journal of Medicinal Plants Studies*, **4**, 13-17.

[94] Prasad, M.P., Prabhu, A., Thakur, M.S. and Ruparel, Y.M. (2013) Phytochemical Screening, Anti-Oxidant Potential and Antimicrobial Activities in Three Species of Cestrum Plants. *International Journal of Pharma and Bio Sciences*, **4**, 673-678.

[95] Taylor, J. (1965) Notes on Lepidoptera in the Eastern Cape Province-5. *Journal of the Entomological Society of southern Africa*, **28**, 137-154.

[96] Bhavana, P.M., Nandhini, S., Vidya, S. and Sanil, R. (2015) Avian Diversity and Dependency in the *Cestrum aurentiacum* Bushes, Nilgiris, India. *International Journal of Pure and Applied Zoology*, **3**, 181-187.

[97] Nilsson, C. and Grelsson, G. (1995) The Fragility of Ecosystems: A Review. *Journal of Applied Ecology*, **32**, 677-692. https://doi.org/10.2307/2404808

[98] Stohlgren, T.J., Otsuki, Y., Villa, C.A., Lee, M. and Belnap, J. (2001) Patterns of Plant Invasions: A Case Example in Native Species Hotspots and Rare Habitats. *Biological Invasions*, **3**, 37-50. https://doi.org/10.1023/A:1011451417418

[99] Jawale, C.S., Vinchurkar, A.S., Dama, L.B., Kishor, P., Dama, S.B. and Yasmeen, S. (2012) *Cestrum nocturnum* (L). A Prospective Piscicide for Control of Predatory

Fish *Channa punctatus* (Bloch.). *Trends in Fisheries Research*, **1**, 14-17.

[100] Jawale, C., Kirdak, R. and Dama, L. (2010) Larvicidal Activity of *Cestrum nocturnum* on *Aedes aegypti*. *Bangladesh Journal of Pharmacology*, **5**, 39-40.

[101] Hewage, C., Bandara, K.A.N.P., Karunaratne, V., Bandara, B.M.R. and Wijesundara, D.S.A. (1997) Insecticidal Activity of Some Medicinal Plants of Sri Lanka. *Journal of the National Science Foundation of Sri Lanka*, **25**, 141-150. https://doi.org/10.4038/jnsfsr.v25i3.5028

[102] Upadhyay, R. (2010) Essential Oils: Anti-Microbial, Antihelminthic, Antiviral, Anticancer and Antiinsect Properties. *Journal of Applied Biosciences*, **36**, 1-22.

[103] Mugera, G.M. and Nderito P. (1968) *Cestrum aurantiacum* d Poisoning in Kenya Livestock. *Bulletin of Epizootic Diseases of Africa*, **16**, 501-506.

[104] Girma, A., Fischer, E. and Dumbo, B. (2014) Vascular Plant Diversity and Community Structure of Nandi Forests, Western Kenya. *Journal of East African Natural History*, **103**, 125-152. https://doi.org/10.2982/028.103.0202

[105] Mande, J.D., Mbithi, P.M.F., Nguhiu-Mwangi, J.A. and Mbiuki, S.M (1993) Cestrum Poisoning in a Young Horse. A Case Report. *Bulletin of Animal Health and Production in Africa*, **41**, 139-141.

[106] Oginosako, Z. (2006) Are They Competing or Compensating on Farm?: Status of Indigenous and Exotic Tree Species in a Wide Range of Agro-Ecological Zones of Eastern and Central Kenya, Surrounding Mt. Kenya: Results of Vegetation, Farmer, and Nursery Surveys. World Agroforestry Centre.

[107] Kenya Forestry Research Institute (KEFRI) (2015) Cestrum Field Day. KEFRI Newsletter Issue No. 15, Jan.-March.

[108] Karanja, R.H., *et al.* (2010) Bee Interactions with Wild Flora around Organic and Conventional Coffee Farms in Kiambu District, Central. *Journal of Pollination Ecology*, **2**, 7-12.

[109] Makokha, J., Kerich, E. and Mkung, D. (2017) Effects of Forest Disturbance on Plant Species Composition and Forest Structure: A Case Study of Kapkanyar Power line in Cherangani Forest. *International Journal of Science and Research*, **6**, 1953-1957.

[110] Nattrass R.M. (1950) *Cestrum aurantiacum* to Be Scheduled as Noxious Weed. K.I.O., 182.

[111] Chebii, W.K. (2016) Assessment of Kenya's Montane Forest Ecosystems: A Case Study on the Cherangani Hills in Western Kenya. *International Journal of Science Arts and Commerce*, **1**, 46-58.

[112] Robertson, K., Goldberg, E.E. and Igić, B. (2011) Comparative Evidence for the Correlated Evolution of Polyploidy and Self-Compatibility in Solanaceae. *Evolution*, **65**, 139-155.

[113] Karawya, M., Rizk, A.M., Hammouda, F.M., Diab, A.M. and Ahmed, Z.F. (1971) Phytochemical Investigation of Certain Cestrum Species. *Planta Medica*, **20**, 363-367. https://doi.org/10.1055/s-0028-1099717

[114] Thorold, P. (1950) *Cestrum aurantiacum* Poisoning. *East African Agricultural and Forestry Journal*, **16**, 114.

[115] Wijesundera, S. (1999) Pathways of Introduction of Invasive Alien Species into Sri Lanka. *Proceedings of* 1*st National Workshop on Invasive Alien Species*, Ministry of Forestry and Environment, Sri Lanka.

[116] Dukes, J.S. and Mooney, H.A. (1999) Does Global Change Increase the Success of Biological Invaders? *Trends in Ecology & Evolution*, **14**, 135-139.

https://doi.org/10.1016/S0169-5347(98)01554-7

[117] Rodrigues, E. and Carlini, E.A. (2006) Plants with Possible Psychoactive Effects Used by the Krahô Indians, Brazil. *Revista Brasileira de Psiquiatria*, **28**, 277-282. https://doi.org/10.1590/S1516-44462006005000014

[118] North West Weeds (2003) Green Cestrum Archived August 20, 2006, at the Wayback Machine.

[119] Colony and Protectorate of Kenya (1921) List of Tree Seeds and Young Trees for Sale, in the Official Gazette. Forest Department, H.M. Stationery Office London, Nairobi, Kenya.

[120] Mande, J.D., Mbithi, P.M.F., Nguhiu-Mwangi, J.A. and Mbiuki, S.M (1993) Cestrum Poisoning in a Young Horse. A Case Report. *Bulletin of Animal Health and Production in Africa*, **41**, 139-141.

[121] Penrith, M.-L., Botha, C.J. and Tustin, R.C. (2015) Plant Poisonings in Livestock in Brazil and South Africa. *Journal of the South African Veterinary Association*, **86**, 1-3. https://doi.org/10.4102/jsava.v86i1.1200

[122] Kellerman, T., *et al.* (2005) Plant Poisonings and Mycotoxicoses of Livestock in Southern Africa. Oxford University Press Southern Africa, Cape Town.

[123] Vahrmeijer, J. (1981) Poisonous Plants of Southern Africa That Cause Stock Losses. Tafelberg Publishers, Ltd., Cape Town.

[124] Shone, D. and Drummond, R.B. (1965) Poisonous Plants of Rhodesia. *Rhodesia Agricultural Journal*, **62**, 1-64.

[125] Mugera, G.M. and Nderito P. (1968) *Cestrum aurantiacum* Poisoning in Kenya Livestock. *Bulletin of Epizootic Diseases of Africa*, **16**, 501-506.

[126] Lavers, D.W. (1953) Green Cestrum—A Plant Poisonous to Stock. *Queensland Agricultural Journal*, **79**, 160-161.

[127] Hubinger, C., *et al.* (2012) Plantas tóxicas do Brasil para animais de producao. Editora Helianthus, Río de Janeiro.

[128] Shaista, A. and Amrita, P. (2016) Delicate, Fragrant, Lady of the Night—A Medicinal Gift. *Journal of Medicinal Plants Studies*, **4**, 13-17.

[129] Connor, H.E. (1977) The Poisonous Plants in New Zealand. E. C. Keating, Government Printer, Wellington.

[130] Meyer, J.-Y. (2004) Threat of Invasive Alien Plants to Native Flora and Forest Vegetation of Eastern Polynesia. *Pacific Science*, **58**, 357-375. https://doi.org/10.1353/psc.2004.0032