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Effects Of *Prosopis Juliflora* On Plant Abundance And Species Diversity Along Riverine Ecosystem Of River Turkwel In Turkana County, Kenya

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Abstract: ***Prosopis species has continued to become one of the most invasive alien species in the region and aggressive invader of the natural ecosystems at an unprecedented rate. This has continued exerting pressure on plant abundance and species diversity altering River Turkwel ecosystem. This study aimed at finding out the effects of Prosopis juliflora on plant abundance and species diversity. Ecological quantitative data was collected by using cross- sectional survey research design. Quadrat sampling method was used to determine plants population size and density. Sampling plots were laid to collect data from the study area. The main sampling plots of 50 m x 30 m (1500 m2) and square quadrats of 5 m x 5 m (25 m2). Simpson's Diversity index was used to calculate the Diversity index. The results illustrated that Prosopis juliflora species showed the highest density and abundance compared to other indigenous plant species along the riparian ecosystem of River Turkwel. The findings have reaffirmed that low species diversity index (D) of 0.791 due to reduced diversity of plant species. The reduced indigenous plant species distribution, species richness and species diversity is as a result of colonization and aggressive nature of the Prosopis species. The study therefore recommends that, there is need to quantify the Prosopis abundance levels in order to protect uninvaded natural riverine ecosystems as well as reversing the trends in biodiversity loss of indigenous plant species.***

Keywords: Prosopis species, plant abundance and species diversity, riverine ecosystem, Invasive alien species

I. INTRODUCTION

Prosopis juliflora (Sw.) DC is one of the invasive species affecting several of the countries in Sub-Saharan Africa. It is native to the Caribbean, South and Central America (Pasiecznik *et al.,* 2001). Prosopis being an invasive alien species have been attributed to the massive loss of biodiversity globally (Niguse and Amara, 2016). In Kenya, *Prosopis juliflora* was introduced in 1980s by the Government of Kenya (GOK) and Norwegian Agency for development cooperation (NORAD). It was purposely introduced to help mitigate desertification and fodder shortages in the Arid and semi-arid lands. *Prosopis Juliflora* is dominant especially along River Turkwel because of sufficient water and fertile soil due to the alluvial deposition with sufficient moisture.

The riverine ecological climatic conditions are assumed to have been ideal for *Prosopis* invasion to colonize River Turkwel riverine ecosystem. Prosopis has become one of the most invasive alien species that could be considered as an aggressive invader of the riverine ecosystem. Greater plant species diversity ensures natural sustainability for all plant forms but this is not the current status as a result of invasive alien species. *P. juliflora* is estimated to have invaded one million hectares (Witt, 2010). Mbaabu *et al*., (2019) found out that the area coverage of *Prosopis juliflora* in Marigat, Baringo County has increased from 882 hectares in 1998 to 18792 hectares in 2016.

The *Prosopis* species was preferred by then local community because of its drought tolerance, fast growth, source of fodder and fuel wood. Unfortunately, the invasion of *Prosopis juliflora* was not managed well hence became

invasive causing ecological impacts that included reduced pasture production on grazing lands and loss of biodiversity among others. The negative effects of invasive species are worsened by climate change and human-induced disturbance. *Prosopis* species has continued to become more invasive and invading riverine ecosystem at an unprecedented rate, exerting strong effect on plant abundance and species diversity hence altering River Turkwel riverine ecosystem. Ng et al., (2016a) mapped out P. *juliflora* coverage within the Tarach water basin in Turkana and found out that 17100 hectares had been densely covered by *Prosopis* species whereas, 51500 hectares is sparsely covered by *Prosopis juliflora*. Similarly, Muturi *et al*., (2013) also established that an estimate of 3 to 27.7 million hectares of the riverine areas in Turkana are highly susceptible to *Prosopis juliflora's* invasion. Specifically, this invasive species has formed an impenetrable thicket along River Turkwell and it is further spreading in the floodplains along these rivers making it difficult to access the rivers.

Therefore, Invasive alien species have attracted the attention of governments, scientists, policymakers, and many other stakeholders globally on the need for them to be brought under control (CBD, 2010; Harageweyn et al., 2013). It is against this background that this study was therefore conducted to evaluate the effect of *Prosopis. juliflora* on plant abundance and species diversity along riverine ecosystem of River Turkwel in Turkana county, Kenya.

II. MATERIALS AND METHODS

A. AREA OF STUDY

The study was conducted in Moi garden about 1.5km from Lodwar town along River Turkwel riverine ecosystem. The choice of River Turkwel was ideal because of *Prosopis* species abundance and species diversity altering River Turkwel riverine ecosystem and its biological invasive nature toward to Lodwar town in Turkana Central Sub-county. The riverine ecosystem is predominated by *Acacia tortilis, Acacia senegal, Acacia melifera, Azadirachta indica, Acacia nubica* and *Hyphaene compressa*, but *Prosop*is species occurrence has continued disrupting ecological system.

B. METHODOLOGY

Ecological quantitative data on the the effect of *Prosopis. juliflora* on plant abundance and species diversity along the riverine ecosystem of River Turkwel was collected by using cross- sectional survey research design. Sampling plots were laid to collect data on plants abundance from the study area. The main sampling plots of 50 m x 30 m (1500 m2), sub-plots of 25 m x 5 m (125 m2) and square quadrats of 5 m x 5 m (25 m2). The sub-plots and square quadrats were nested within the main plots which were in turn laid down along line transect belts. The line transect of length 50 m was laid down a long river Turkwel, a distance of 11.5m from the River water source. Quadrat and line transect methods were used to determine plants population size and density. Plant species were distributed randomly (random dispersion) without a predictable pattern. The population of the plant species were based on the number that fall within the line transact and quadrats transact area of study identified.

Ecological quantitative data were collected by direct counting of plant species in the habitat and analysis was done as per Sherman (2005); Basistha et. al (2010) and Misra (1968). Simpson's Diversity index was used to calculate the Diversity index. Formula used to measure plants abundance and Species Diversity were as follows:

FREQUENCY

$$\text{Frequency (\%)} = \frac{\text{No. Of quadrats in which the species occurred}}{\text{Total number of quadrats studied}} \times 100$$

DENSITY

$$\text{Density} = \frac{\text{Total number of individuals of a species in all quadrats}}{\text{Total number of quadrats studied}}$$

ABUNDANCE

$$\text{Abundance} = \frac{\text{Total number of individuals of a species in all quadrats}}{\text{Total number of quadrats in which species occurred}}$$

RELATIVE FREQUENCY

$$\text{Relative frequency} = \frac{\text{Frequency of the species}}{\text{Total frequency of all the species}} \times 100\%$$

RELATIVE ABUNDANCE

$$\text{Relative abundance} = \frac{\text{Abundance of the species}}{\text{Total abundance of all the species}} \times 100$$

RELATIVE DENSITY

$$\text{Relative density} = \frac{\text{Density of the species}}{\text{Total density of all the species}} \times 100$$

IMPORTANT VALUE INDEX (IVI)

Important value index= Relative density+ Relative frequency+ Relative abundance

Simpson's Diversity index (D). It gives a better measures of diversity of species in a community.

Denoted as *D*, this Diversity index is calculated as:

$$D = \frac{\Sigma n1\ (\ n1\text{-}1)}{N(N\text{-}1)}$$

III. RESULTS AND DISCUSSIONS OF THE FINDINGS

Table 1 and Table 2 showed the results obtained on primary ecological parameters from the study site. Five plant tree species, two herbs, one grass species and one climber were observed in the study area. In terms of density, abundance and frequency, the most densely populated plant species was *Prosopis juliflora* with relative density of 70.31 %; 88.52 % and relative abundance of 63.88 %; 84.32 % (Table 1 and Table 2). The most frequently observed plant species in the study area with the highest relative frequency of 17.24 % and 33.33% was *Prosopis juliflora*, followed by

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Hyphaene compressa, the herb species and climbers. The least relative density and abundance value was observed in *Acacia nubica* and *Acacia tortlis* plant species with relative density value of 13.33 % and 6.67 % respectively.

Scientific name	Individuals	Species occur	Density	Frequency	Abundance	Relative Density	Relative Abundance	Relative Frequency	Important Value Index (IVI)
Prosopis juliflora	540	5 out of 5	108	100	108	70.31	63.88	17.24	`151.43
Hyphaene compressa	55	4 out of 5	11	80	13.75	7.16	8.13	13.79	29.08
Azadirachta indica	10	3 out of 5	2	60	3.33	1.30	1.97	10.34	13.61
Acacia tortilis	4	2 out of 5	0.8	40	2	0.52	1.18	6.90	8.60
Acacia nubica	1	1 out of 5	0.2	20	1	0.13	0.59	3.45	4.17
Herb spp. (x)	40	4 out of 5	8	80	10	5.21	5.91	13.79	24.91
Herb spp. (y)	57	4 out of 5	11.4	80	14.25	7.42	8.43	13.79	29.64
Grass species (x)	55	4 out of 5	11	80	13.75	7.16	8.13	13.79	29.08
Climber (x)	6	2 out of 5	1.2	40	3	0.78	1.77	6.90	9.46
	N= 813		**Σ 153.6**	**Σ 580**	**Σ 169.08**	**Σ 99.99**	**Σ 99.99**	**Σ 99.99**	**Σ 300.204**

Table 1: Primary Ecological Parameters Of River Turkwel Riverine Ecosystem

Scientific name	Individuals	Density	Frequency	Abundance	Relative Density	Relative Abundance	Relative Frequency	Important Value Index (IVI)
Prosopis juliflora	540	108	100	108	88.52	84.32	33.33	`206.17
Hyphaene compressa	55	11	80	13.75	9.01	10.74	26.67	46.42
Azadirachta indica	10	2	60	3.33	1.64	2.60	20	24.24
Acacia tortilis	4	0.8	40	2	0.66	1.56	13.33	15.55
Acacia nubica	1	0.2	20	1	0.16	0.78	6.67	7.61
	N= 610	**Σ 122**	**Σ 300**	**Σ 128.08**	**Σ 99.99**	**Σ 100**	**Σ 100**	**Σ 300.204**

Table 2: Importance Value Index (Ivi) And Priority Class For Indigenous Trees Species In Riverine Ecosystem Of River Turkwel

Simpson's Diversity index (D)

$$D = \frac{\Sigma n1\,(n1-1)}{N(N-1)} = \frac{294.132}{610\,(610-1)}$$

D = 0.791. The bigger the value, the lower the species diversity and species richness

The results have showed that the most densely populated plant species was *Prosopis juliflora* with the highest population and the relative density followed by *Hyphaene compressa*, *Azadirachta indica*, *Acacia nubica*, grass species and lastly *Acacia nubica* with their ecological parameters (Table 1 and Table 2). This could explain the typical adaptability characteristic of Prosopis juliflora of rapid growth and spreading habit of colonizing riverine ecosystem. The high abundance and density of *Prosopis juliflora* is attributed to its ecological adaptability and interference to a wide range of ecological conditions such as riverine ecosystems that forms favorable driving factors to its widespread distribution and abundance along the riverine ecosystem of River Turkwel. The findings have confirmed that Prosopis species was able to outcompete native plants for limited resources with such ecological habitat and conditions.

The study site has showed low diversity index (D) of 0.791 due to reduced diversity of plant species. Reduced species diversity in the area colonized by *Prosopis juliflora* could suggest the negative influence of *Prosopis juliflora* on the regeneration and establishment of other native species (Clement *et. al*, 2020). The high abundance and density of *Prosopis species* could be associated with extreme reduction of indigenous tree species that have become endangered overtime since introduction of Prosopis species leading to reduced species diversity. The results have confirmed that the reduced tree species distribution, richness and diversity is due to colonization of the riverine ecosystem by the Prosopis species. The Prosopis species has continued to become lethal and invasive in nature because of its massive seed production throughout the season and its mode of seed dispersal which is mainly through livestock and water as a conveyor belts of spreading and distribution along the riverine ecosystem. The most abundant plant species was still *Prosopis juliflora* followed by *Hyphaene compressa.* The results have confirmed that *Prosopis juliflora species* has the highest density and abundance compared to other indigenous plant species along the riparian ecosystem. The *Prosopis species* was more dominant than other plant species because it grows without human care and less vulnerable to disturbances caused by human activities. El-Keblawy and Abdelfatah (2014) reported that invasive alien species can dominate the native species easily and successfully out-compete them. This is in agreement with El-Keblawy and Al-Rawai (2007) who reported that *Prosopis species* has showed to exhibit smoother plants underneath characteristics because of its distinguishing canopy feature which is thicker than those of native plants.

Acacia tortilis had the lowest relative density due to human population demand that is increasing and encroachment into the riverine ecosystem of River Turkwel. Clearance of land for development activities such preparing campaign grounds and agricultural activities along the Riverine Ecosystem. This showed that the high abundance of *Prosopis juliflora* and its widespread distribution within the riverine ecosystem is largely contributed due to its ecological adaptability to numerous seed production, seed germination and successful mechanism of seed dispersal by animals feeding on them. Findings by Ng *et al*., (2018) mapped out *P. juliflora* coverage within the Tarach water basin in Turkana and found out that 17100 hectares had been densely covered by *Prosopis* species whereas, 51500 hectares is sparsely covered by *P. juliflora*.

Similarly, Muturi *et al*., (2013) also established that an estimate of 3 to 27.7 million hectares of the riverine areas in Turkana are highly susceptible to *P. juliflora's* invasion. The high spread and rapid growth of *Prosopis species could be* associated with its colonization selection pressure and ability to produce numerous seed production at very higher rate compared to indigenous tree species. The findings are in concurrence with results of Clement *et.al* (2020) who reported that *Prosopis* possess its invasive potential due to its massive seed production throughout the season and mode of seed

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dispersal by livestock and water. Ellstrand and Schierenbeck (2000) found out that the invasive alien species have the ability to decrease native species abundance as well as changing the community structure (Hejda *et al.*, 2009) and alter genetic diversity (Gaertner *et al.*, 2009). *Prosopis juliflora* has allelopathic effects that hinder the growth of the native plant species.

IV. CONCLUSIONS

The results have showed that *Prosopis juliflora* was more abundant with high relative density and population. The riverine ecosystem colonized by high diversity and abundance of Prosopis species has led to reduction of species diversity of other indigenous species. This has clearly demonstrated that the *Prosopis* species has altered the riparian ecosystem structure due to invasive and allelopathic nature. The high presence of Prosopis could have detrimental effects to indigenous plant ecosystems and species richness by suppressing growth of native plant species in the riverine ecosystem.

V. RECOMMENDATIONS

The study recommends that there is need not only to employ multi-sectoral approach in terms of effective control and management strategies of Prosopis species but there is need to quantify the abundance levels and extent of its spread in order to protect yet uninvaded natural riverine ecosystems to address its invasion rate and ecological adaptability to such ecosystems.

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