Scientific Research Publishing

Current Urban Studies, 2020, 8, 533-544
https://www.scirp.org/journal/cus
ISSN Online: 2328-4919
ISSN Print: 2328-4900

Spatial Ramifications of Dodder Infestation on Urban Ornamentals in Mombasa, Kenya

Innocent Osoro Ngare[1*], James Kibii Koske[1], John Njagi Muriuki[1], George Njagi Gathuku[2], Ruth Kangai Adiel[1]

[1]Department of Environmental Science & Education, School of Environmental Studies, Kenyatta University, Nairobi, Kenya
[2]School of Hospitality & Tourism, Strathmore University, Nairobi, Kenya
Email: *ngare.innocent@gmail.com

How to cite this paper: Ngare, I. O., Koske, J. K., Muriuki, J. N., Gathuku, G. N., & Adiel, R. K. (2020). Spatial Ramifications of Dodder Infestation on Urban Ornamentals in Mombasa, Kenya. *Current Urban Studies, 8,* 533-544.
https://doi.org/10.4236/cus.2020.84029

Received: September 8, 2020
Accepted: December 4, 2020
Published: December 7, 2020

Abstract

Dodders are cosmopolitan generalist holoparasites that forage on a community of plant species ranging from shrubs, trees and herbaceous. In this study, we employ mixed method research design that involved use of questionnaires and dodder host sampling matrix. Host identification and naming was carried out by ecological Android PlantNet Plant App version 3.0.5. Respondents sample size was determined by Krejcie and Morgan sampling formula. Results show that dodder was fast spreading through spatial retrospective satellite Landsat imagery analysis. Dodder was known by the majority of respondents (97.1%) where the exploratory analysis score shows that respondents' constituency of residence influenced their understanding of dodder ($F(5, 361) = 5.329$, $P = 0.000$). The mode of parasitism between dodder & the hosts varied as some ornamental trees, shrubs and herbaceous plants were either affected moderately or extremely. The study recommends use of biotechnological dodder control approaches through transgenic plants biotechnology and plant breeding to develop resistance towards dodder plant parasites.

Keywords

Parasite, Forage, Ravage, Obligate, Host

1. Introduction

Dodders (*Cuscuta sp.*) are classified under the Morning-glory family, commonly referred to as Convolvulaceae. However, different authors (Small, 1933; Gandhi & Thomas, 1987: p. 361; Mishra & Dixit, 2019: p. 420) differ with the morning glory family classification classifying them to the specific family Cuscustaceae.

The current phylogenetic studies by Stefanovic et al. 2003 and Neyland, 2001, suggest that their genus is nested in monophyletic Convolvulaceae terming Cuscuta, a member of this family. Morphologically, Cuscuta is leafless, obligating with twinning flexibility, with yellowish or orange haustoria stems (having specialized stems with sucking roots). These artificial roots aid dodder ability to penetrate their hosts and extract nutrients (Dawson et al., 1994; Zhuang et al., 2018). Dodder produces small flowers (approximately 7 mm in length or less) that have waxy textures with whitish corollas.

Sherman et al. 2008 indicate that, dodder seeds germinate in the soil before their rudimentary roots (swollen root-like small structures) parasitize host plant, twinning itself with its roots falling or dying within a few days. This death of roots is known as haustoria. Dodders are cosmopolitan obligate parasites that are purely weedy and causing damage to host plant species (Lanini & Kogan, 2005; Flores-Sánchez & Garza-Ortiz, 2019). The authors add that they obtain all of their growth requirements (water, minerals, and carbohydrates) by attaching to host plants. Dodder category of hosts includes; ornamental plants, plants grown for agricultural purposes, and rangeland plants (Hegenauer et al., 2018).

In Africa, dodders have ravaged ornamentals across Sub-Saharan Africa urban areas proliferated by urban ecological footprint (**Figure 1(a)** & **Figure 1(b)**). People move in and out of cities (Nairobi, Kampala, Mombasa, Kishasa) within the local setting, across the region and internationally. Contaminated obtained products via imports give a leeway to the spread of dodder. According to Namayo (2020), a deadly plant vine parasite has ravaged ornamentals in Kampala and is fast spreading to other cities in Sub-Saharan Africa. The parasite strangles planted aesthetic vegetation along the roads and eventually exterminates the vegetation. Most vulnerable plants within the urban suburbs include the *Duranta repens*, *Ficus benjamina* and *Acalypha cuneata*. Commonly known as field dodder, this species is ravaging both the urban and rural ecosystems in Kenya.

Dodder affects urban ornamental plants by causing a severe drain to the host

(a) (b)

Figure 1. Show dodder infestation on urban ornamentals at major urban cities in East Africa. (a) Dodder infestation on *Durunta erecta* sp. being attacked in Nairobi (Source; author 2020). (b) Dodder on ornamental tree in Kampala (Source; Namayo, 2020).

plant resources and often ultimately preventing their healthy development (Shiferaw et al., 2018; Sarić-Krsmanović, 2020). In Kenya, this holoparasite has terrorized ornamental plants in urban areas that are grown for aesthetics, fencing and in small household gardens. Dodders threaten the survival of biodiversity in Kenya. Therefore, this study was conducted in Mombasa County's urban ecological zones to ascertain the degree of infestation and destruction caused by dodder on urban ornamental plants grown in the coastal region. Vulnerable species are sampled and identified and recommendations made on dodder probable effective control method.

2. Materials and Methods

2.1. Research Design

This study used a mixed method research design that involved use of questionnaires and dodder sampling matrix to obtain primary data through an exploratory survey. Closed ended questionnaires were used to collected; respondents biodata; sampled location via recording of coordinates and general understanding of dodder by the respondents. Sampling matrix host sampled foraged plants and the extent they were infested. Identification of ornamental species was through PlantNet Plant Android App version 3.0.5. To establish the degree of spread of dodder in Mombasa County, a five-year retrospective study was conducted using Landsat imagery maps. This shows the level of infestation between 2014 and 2019. Different infested points coordinates were taken in Mombasa County to assess the extent to which dodder was fast spreading. The coordinates were mapped on Google maps to locate the epicenter of dodder ravaged areas. The findings are anchored in a five-year period. From the retrospective study, the level of infestation is shown in **Figure 4** and **Figure 5** generated from Google maps and satellite Landsat imagery. Distribution of dodder weed in years 2014 and 2019 is shown respectively.

2.2. Sample Size

Krejcie and Morgan (1970) formula determined the sample size of a finite population through the equation;

$$S = \chi^2 NP(1-P) \big/ d^2 (N-1) + \chi^2 P(1-P) \quad (1)$$

where:

χ^2 = table value of Chi-Square @ 1 DF at a desired confidence level of (3.84),

N = population size, in this case 268,700,

P = population proportion (assumed to be 0.5 since this would provide the maximum sample size),

d = the degree of accuracy expressed as a proportion (0.05).

Therefore, giving 384 as the least sample size from a given finite population (P) thus sample size was in the range of plus or minus 0.05 of the population proportion with a 95% level of confidence.

2.3. Study Area

This study was conducted in Mombasa County, Kenya. The county lies in latitude of −4˚S and longitude of 39˚E (Figure 2). The county is among the forty-seven counties that make up the Kenyan Republic. Mombasa County is made up of six sub-counties namely; Kisauni, Jomvi, Changamwe, Likoni, Mvita and Nyali. Geographically, the county is estimated to cover 229.9 km^2 with a water mass cover of 65 km^2. Along its coastline, approximately 3000 hectares dominated by mangrove forest. Topographically, is gentle with the highest altitude of 132 m and lowest of 45 m. Mombasa County has an annual temperature of 27.9˚C with a temperature range of between 22.7˚C to 33.1˚C. The county receives an average annual rainfall of approximately 640 mm. The coastal monsoon winds influence the climate of the Mombasa as the county lies along the hot tropical coastal strip (CIDP, 2018).

3. Results and Discussion

3.1. Knowledge on Dodder in Constituencies

The study wanted to establish if the respondents knew what the dodder weed was and hence, they were shown a pictorial dodder sample (Figure 3), then asked questions to confirm if they were familiar with the weed.

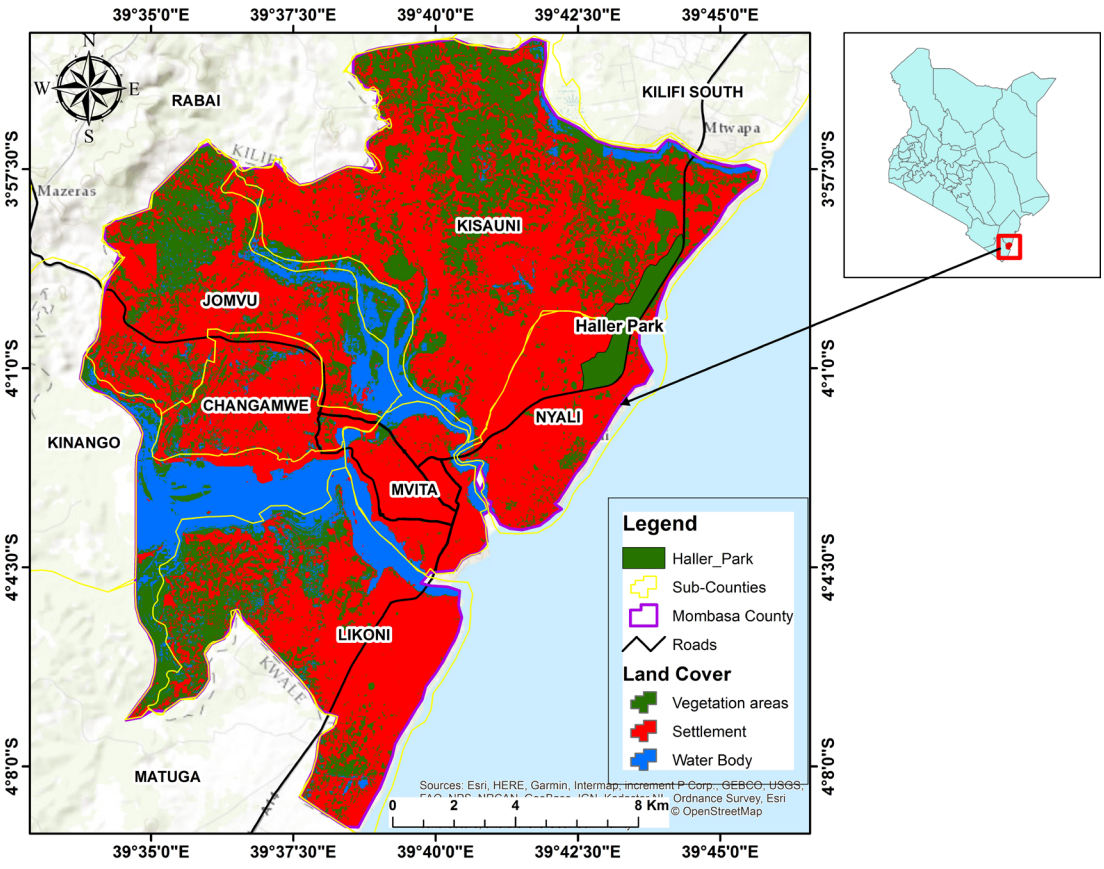

Figure 2. Map of the study area.

Nearly all the respondents (97.1%) claimed to have known the weed with a small portion (2.7%) acknowledging that they do not know the plant. To examine further their knowledge about the dodder, Likert scale was applied to collect opinions from the respondents to ascertain their understanding on dodder weed. Afterwards, a Likert scale was developed, which measured the understanding score of dodders, and a one-way ANOVA performed to test for any significant variations. After performing some exploratory analysis on the data, it emerged the constituency that a respondent came from had an influence on the score (Table 1).

The results in Table 1 are from a one-way ANOVA analysis that was performed to check if there was any significant difference in the mean score of the understanding of dodder weed between respondents of the six constituencies that took in this survey. The output shows that there is a significant difference in the mean scores of the understanding of dodder weed for at least one constituency at 0.05 level of significance; $F(5, 361) = 5.329$, $P = 0.000$. This is an indication that some constituents have a better understanding of the weed compared to others. In order to establish the constituency(s) that significantly differed from the rest, a Least Significant Difference (LSD) test was performed on the data and the output is as shown in Table 2.

The multiple comparison table shows that the mean understanding score of dodder weed for residents of Kisauni (MD = 2.733, $P = 0.067$) is significantly different at 0.05 level of significance from the residents of Nyali (MD = −3.456,

Figure 3. Dodder foraging on a plant in Kisauni Constituency, Researcher, 2019.

Table 1. One-way ANOVA test.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1658.654	5	331.731	5.329	0.000
Within Groups	22472.340	361	62.250		
Total	24130.995	366			

Table 2. Least significance difference test.

Multiple Comparisons						
(I) Constituency	(J) Constituency	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Kisauni	Jomvi	2.733	1.488	0.067	−0.19	5.66
	Nyali	3.546*	1.302	0.007	0.99	6.11
	Changamwe	7.173*	1.401	0.000	4.42	9.93
	Likoni	2.884*	1.354	0.034	0.22	5.55
	Mvita	3.305*	1.380	0.017	0.59	6.02
Jomvi	Kisauni	−2.733	1.488	0.067	−5.66	0.19
	Nyali	0.813	1.499	0.588	−2.14	3.76
	Changamwe	4.439*	1.586	0.005	1.32	7.56
	Likoni	0.151	1.545	0.922	−2.89	3.19
	Mvita	0.572	1.567	0.715	−2.51	3.65
Nyali	Kisauni	−3.546*	1.302	0.007	−6.11	−0.99
	Jomvi	−0.813	1.499	0.588	−3.76	2.14
	Changamwe	3.627*	1.413	0.011	0.85	6.41
	Likoni	−0.662	1.367	0.628	−3.35	2.03
	Mvita	−0.241	1.392	0.863	−2.98	2.50
Changamwe	Kisauni	−7.173*	1.401	0.000	−9.93	−4.42
	Jomvi	−4.439*	1.586	0.005	−7.56	−1.32
	Nyali	−3.627*	1.413	0.011	−6.41	−0.85
	Likoni	−4.289*	1.461	0.004	−7.16	−1.41
	Mvita	−3.868*	1.485	0.010	−6.79	−0.95
Likoni	Kisauni	−2.884*	1.354	0.034	−5.55	−0.22
	Jomvi	−0.151	1.545	0.922	−3.19	2.89
	Nyali	0.662	1.367	0.628	−2.03	3.35
	Changamwe	4.289*	1.461	0.004	1.41	7.16
	Mvita	0.421	1.441	0.770	−2.41	3.26
Mvita	Kisauni	−3.305*	1.380	0.017	−6.02	−0.59
	Jomvi	−0.572	1.567	0.715	−3.65	2.51
	Nyali	0.241	1.392	0.863	−2.50	2.98
	Changamwe	3.868*	1.485	0.010	0.95	6.79
	Likoni	−0.421	1.441	0.770	−3.26	2.41

$P = 0.007$), Changamwe (MD = −7.173, $P = 0.000$), Likoni (MD = −2.844, $P = 0.034$) and Mvita (MD = −3.305, $P = 0.017$). The inhabitants of Kisauni understood the dodder weed better compared to the other sub-counties except Jomvi

(MD = −2.733, $P = 0.067$). The mean score of dodders understanding at Jomvi was found to be significantly different from that of Changamwe. Except Kisauni, the mean understanding score of dodder weed in for the Nyali residents was significantly different from that of Changamwe. Also, the mean score of Changamwe was different from that of Likoni and Mvita.

3.2. Geographical Spread of Dodder in Mombasa

The spatial Landsat imagery in Figure 4, shows distribution of dodder in Mombasa County in the year 2014. Among the six sampled constituencies, Kisauni showed to be infested more compared to other constituencies as indicated by spatial coordinates mapping spread on the map modelled by settlement, vegetation, bare land and constituency features. Dodder was dominant in areas with vegetation and grasslands with emerging urban sprawl north east of Kisauni.

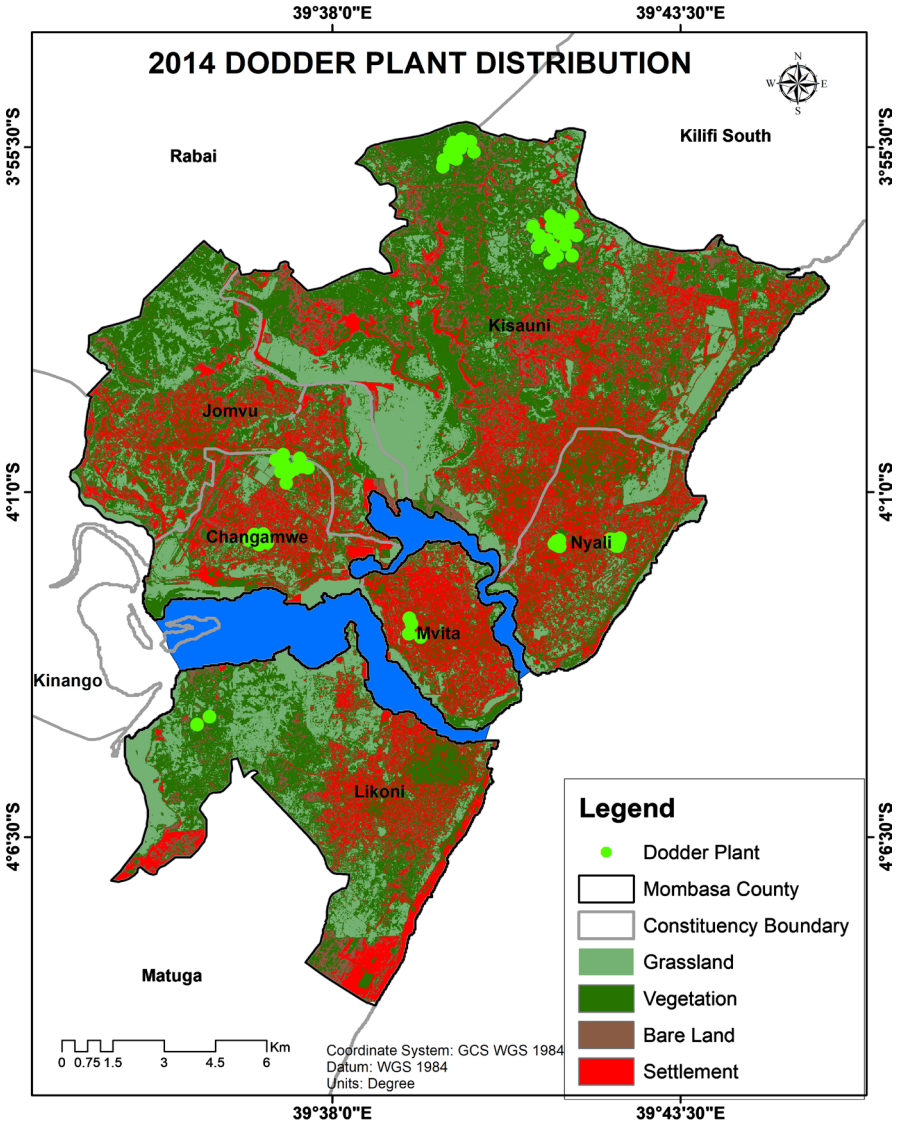

Figure 4. Distribution of dodder weed in Mombasa in 2014.

Infestation patches had begun proliferation in Likoni towards the coastline and parts of Mvita and Nyali where urban sprawl was intense. This observation aligns with that of Hegenauer et al., 2018, where dodders attacks a range of different categorized hosts from herbaceous to shrubs.

Dodder infestation has surged in the past five years as shown in Figure 5. Compared to Figure 4, Landsat imagery outlines fast spread of dodder in Likoni and Kisauni and parts of Changamwe. In Nyali, dodder was attacking host along Haller Park and Mutamboni. This fast infestation was propagated by environmental extremes and human activities along the areas. This attributes to analytical retrospective findings on climate variability effect at the coastal region of Kenya (Ngare et al., 2020).

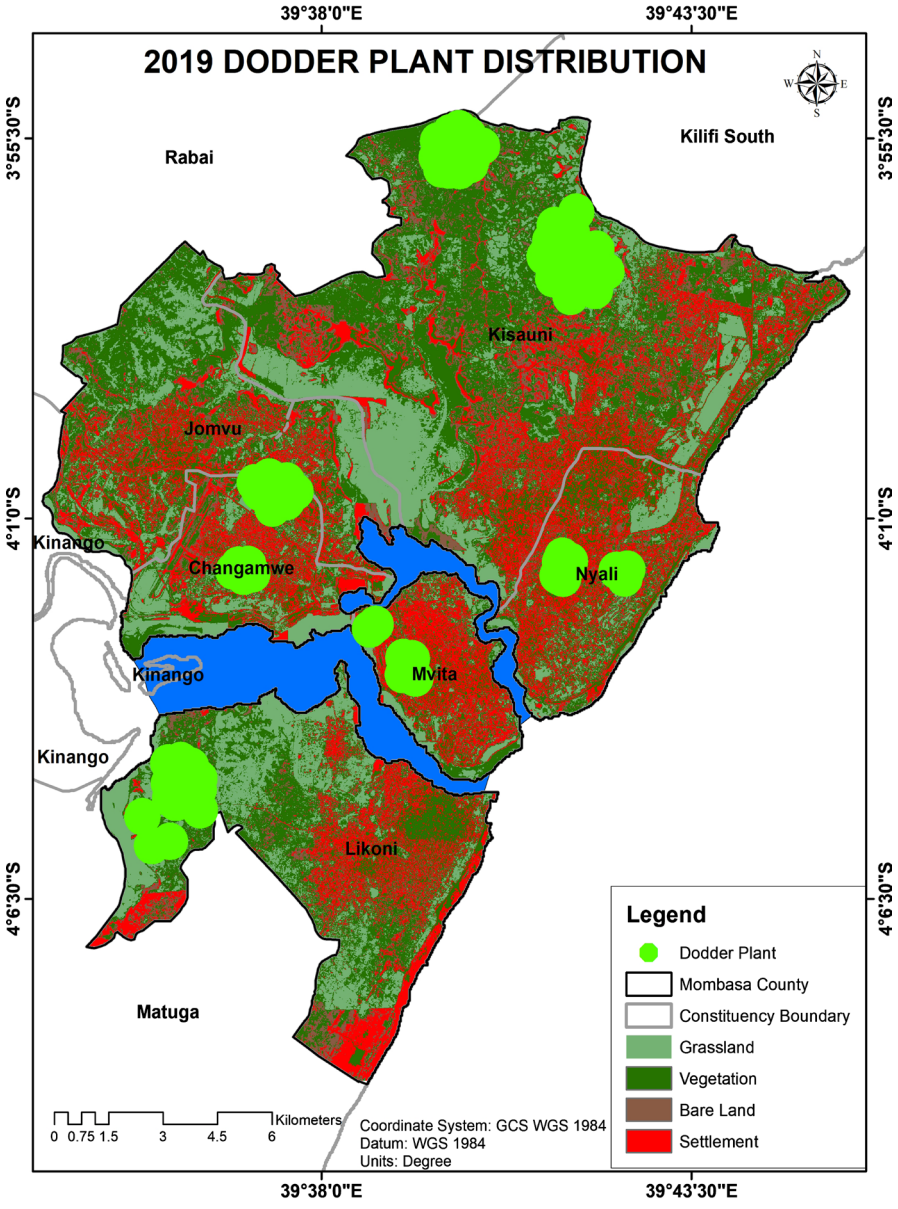

Figure 5. Distribution of dodder weed in Mombasa County in 2019.

3.3. Identified Dodder Ornamental Hosts

The extent dodder foraged on different plant species is shown in Table 3. The sampled plant hosts have been identified through their classifications; tree, shrub and herbaceous that exist at the coast. To distinguish them, their botanical names have been outlined in brackets. Some species have experienced extreme infestation, such as *Azadirachta indica*, *Solanum incanum*, *Thevetia thenotroides* and *Pelargonium zonale.* Those that were affected moderately included *Bauhinia variegate*, *Acacia nilotica* and *Rhoicissus tridentate*. Dodder was affecting both indigenous and exotic plants across all the three classifications.

Dodders forage differently depending on their interaction with the host. The findings in Table 3 indicate that dodders are generalist holoparasites with heterogeneous community of plants that the forage on. For instance, they attach hosts from different genera. This arrays from trees, shrubs and herbaceous plant species classification in taxonomy. According to (Koch et al., 2004; Runyon et al., 2006) dodders have a range of different hosts it attacks. However, the degree of parasitism depends on the interaction that is determined by the flow of nutrients from the hosts vascular bundles, the xylem and phloem (Těšitel, 2016).

Table 3. Sample matrix for indigenous and exotic dodder hosts in Mombasa County.

	***Species name* (*Botanical name*)**	***Classification***			***Origin* (*Indigenous or Exotic*)**	
		Tree	**Shrub**	**Herbaceous**		
	Identified Plant Host				**Intensity of Parasitism**	
1.	Horse flower (*Pelargonium zonale*)			✓	Indigenous	Extreme
2.	Neem tree (*Azadirachta indica*)	✓			Exotic	Extreme
3.	Egyptian thorn (*Acacia nilotica*)	✓			Indigenous	Moderate
4.	Camel's foot (*Bauhinia variegate*)		✓		Exotic	Moderate
5.	Tasmania blue gam (*Eucalyptus globulus*)	✓			Exotic	Moderate
6.	Umbrella tree (*Terminali montaly*)	✓			Exotic	Extreme
7.	Yellow oleander (*Thevetia thenotroides*)	✓			Exotic	Extreme
8.	Whistling thorn (*Acacia derepanalobium*)		✓		Indigenous	Moderate
9.	Mauritious thorn (*Caesalpinium delecapetala*)		✓		Exotic	Moderate
10.	Kai apple (*Dovyalis caffra*)		✓		Exotic	Extreme
11.	Milk bush (*Euphobia tirucalli*)				Indigenous	Moderate
12.	Sodom apple (*Solanum incanum*)		✓		Indigenous	Extreme
13.	Bushman's grape (*Rhoicissus tridentate*)			✓	Exotic	Moderate
14.	Bitter apple nightshade (*Solanum incanum*)		✓		Indigenous	Moderate
15.	Sedge grass (*Cyperus esculentus*)			✓	Exotic	Moderate
16.	Pencil tree (*Euphorbia tirucalli*)		✓		Indigenous	Extreme
17.	Pigeonberry (*Duranta erecta*)		✓		Exotic	Extreme
18.	Weeping tree (*Ficus benjamina*)	✓			Exotic	Moderate
19.	Chenille plant (*Acalypha hispida*)		✓		Exotic	Extreme

Therefore, the observed level of parasitism from the results across different species agrees with this study.

4. Research Limitations

This study was conducted in Mombasa County and it was anchored by both fieldwork and laboratory work to identify dodders species and hosts samples. The noted limiting factors from the study included:

1) The unrelated nature of dodders and their morphological features that have evolved overtime within their genera. Distinguishing dodders by phenotype appear similar however genotype could give a clear taxonomical identity.

2) Some dodder hosts could not be parasitized even within their sampling scope. Therefore, allelopathy defense mechanisms shown by some hosts like acacia could enhance further interior sampling to obtain ravaged samples.

5. Conclusion

The spatial retrospective analysis shows fast proliferating spread of dodder in Mombasa foraging on different plant hosts grown as urban ornamentals that are both exotic and indigenous. Predominant dodders in the area were *C. competris* and *C. florimis* that were fast spread. These common dodder species in Mombasa are generalist holoparasites infesting shrubs, trees and herbaceous plant species. The residents within the coastal town suburbs across the county's constituencies were familiar with dodder parasite and its existence. Therefore, the presence of dodder was felt, ravaging existing ornamentals different ornamental plant species moderately or extremely affecting their growth.

6. Recommended Control Measures

- Use of biotechnological dodder control approaches. This involves; transgenic plants biotechnology and plant breeding to develop resistance towards dodder plant parasites.
- Persistent application of herbicides to eradicate notorious ramifications of dodder parasitism on hosts.
- Use of mechanical control measures but with high level of caution to avoid probable spread of the weed parasite.
- Capacity building to the community in high dodder ravaged areas to enhance monitoring and control of dodder spread.

Acknowledgements

Our word of thanks to Kenyatta University school of environmental studies for their review and comments for the early version of manuscript for this article.

Conflicts of Interest

The authors declare no competing interest.

References

CIDP (2018). *County Government of Mombasa-CGoM. Second County Integrated Development Plan*. http://www.mombasa.go.ke/wp-content/uploads/2018/11/MSA-FINAL-CIDP-2018-22.pdf

Dawson, J. H., Musselman, L. J., Wolswinkel, P., & Dörr, I. (1994). Biology and Control of Cuscuta. *Reviews of Weed Science, 6,* 265-317.

Flores-Sánchez, I. J., & Garza-Ortiz, A. (2019). Is There a Secondary/Specialized Metabolism in the Genus Cuscuta and Which Is the Role of the Host Plant? *Phytochemistry Reviews, 18,* 1299-1335. https://doi.org/10.1007/s11101-019-09649-5

Gandhi, K. N., & Thomas, R. D. (1987). Cuscustaceae of Louisiana. *Sida, 12,* 361-379.

Hegenauer, V., Körner, M., & Albert, M. (2018). Plants under Stress by Parasitic Plants. *Current Opinion in Plant Biology, 38,* 34-41. https://doi.org/10.1016/j.pbi.2017.04.006

Koch, A. M., Binder, C., & Sanders, I. R. (2004). Does the Generalist Parasitic Plant *Cuscuta campestris* Selectively Forage in Heterogeneous Plant Communities? *New Phytologist, 162,* 147-155. https://doi.org/10.1046/j.1469-8137.2004.00999.x

Krejcie, R. V., & Morgan, D. W. (1970). Determining Sample Size for Research Activities. *Educational and Psychological Measurement, 30,* 607-610. https://doi.org/10.1177/001316447003000308

Lanini, W., & Kogan, M. (2005). Biology and Management of *Cuscuta* in Crops. *Ciencia e Investigación Agrarian, 32,* 165-179. https://doi.org/10.7764/rcia.v32i3.317

Mishra, S., & Dixit, N. (2019). Investigations on Anti-Bacterial Effect of Extract *Cuscuta reflexa*. *Asian Journal of Pharmacy and Pharmacology, 5,* 419-424. https://doi.org/10.31024/ajpp.2019.5.2.28

Namayo, A. (2020). *Dangerous Plant Invades Kampala*. https://www.newvision.co.ug/new_vision/news/1503872/dangerous-plant-invades-kampala-city

Neyland, R. (2001). A Phylogeny Inferred from Large Ribosomal Subunit (26S) rDNA Sequences Suggests That Cuscuta Is a Derived Member of Convolvulaceae. *Brittonia, 53,* 108-115. https://doi.org/10.1007/BF02805402

Ngare, I. O., Koske, J. K., Muriuki, J. N., Chitechi, E. W., & Gathuku, G. N. (2020). Urban Climate Variability Trend in the Coastal Region of Mombasa Kenya. *African Journal of Environmental Science and Technology, 14,* 214-221. https://doi.org/10.5897/AJEST2020.2837

Runyon, J. B., Mescher, M. C., & De Moraes, C. M. (2006). Volatile Chemical Cues Guide Host Location and Host Selection by Parasitic Plants. *Science, 313,* 1964-1967. https://doi.org/10.1126/science.1131371

Sarić-Krsmanović, M. (2020). Field Dodder: Life Cycle and Interaction with Host Plants. In *Co-Evolution of Secondary Metabolites* (pp. 101-120). Berlin: Springer. https://doi.org/10.1007/978-3-319-96397-6_58

Sherman, T. D., Bowling, A. J., Barger, T. W., & Vaughn, K. C. (2008). The Vestigial Root of Dodder (*Cuscuta pentagona*) Seedlings. *International Journal of Plant Sciences, 169,* 998-1012. https://doi.org/10.1086/590442

Shiferaw, W., Demissew, S., & Bekele, T. (2018). Invasive Alien Plant Species in Ethiopia: Ecological Impacts on Biodiversity a Review Paper. *International Journal of Molecular Biology, 3,* 169-176. https://doi.org/10.15406/ijmboa.2018.03.00072

Small, J. K. (1933). *Manual of the Southeastern Flora*. Chapel Hill, NC: Univ. of North

Carolina Press.

Stefanovic, S., Austin, D. F., & Olmstead, R. G. (2003). Classification of Convolvulaceae: A Phylogenetic Approach. *Systematic Botany, 28,* 791-806.

Těšitel, J. (2016). Functional Biology of Parasitic Plants: A Review. *Plant Ecology and Evolution, 149,* 5-20. https://doi.org/10.5091/plecevo.2016.1097

Zhuang, H., Li, J., Song, J., Hettenhausen, C., Schuman, M. C., Sun, G., Wu, J. et al. (2018). Aphid (*Myzus persicae*) Feeding on the Parasitic Plant Dodder (*Cuscuta australis*) Activates Defense Responses in Both the Parasite and Soybean Host. *New Phytologist, 218,* 1586-1596. https://doi.org/10.1111/nph.15083