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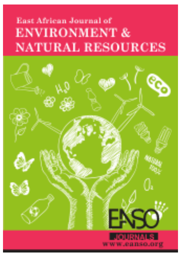

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Original Article

An Invasive Plant Parthenium hysterophorus Reduces Native Forage Cover

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ABSTRACT

While some research has been conducted in sub–Saharan Africa on the alien invasive *Parthenium hysterophorus*, little work has assessed whether it is poses negative impact on native forages. A field survey was carried out to study the dominant co–existing plant species, and its impact on plant abundance, species, and native forage cover. We found that non–natives were the dominant co–existing plants with *P. hysterophorus* compared to natives. Plant species (r = -0.889, P = 0.043) and abundance (r = -0.968, P = 0.007) decreased with increasing invasive percent cover. Moreover, native forage plant (*Brachiaria reptans*; r = -0.922, *P* = 0.026), *Cynodon dactylon*; r = -0.972, *P* = 0.006, *Digitaria milanjiana*; r = -0.938, *P* = 0.018, and *Indigofera spicata;* r = -0.977, *P* = 0.004) percent cover decreased with increasing invasive percent cover. The study concludes that *P. hysterophorus* negatively affects plant diversity, and thus, should controlled.

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INTRODUCTION

Many exotic or non-native plant species have been accidently or purposefully introduced to other nations (Early *et al.,* 2016; Pratt *et al.,* 2017). In native and semi-natural habitats, several of these plants have established and some have now become significant invasive alien plant species (IAPs) (Witt & Luke, 2017). Human activities, including the introduction of plants for food, agroforestry, ornamentation, and forestry, for instance, have been reported to be the significant cause for the spread of IAPs (Dawson *et al.,* 2008). In addition to anthropogenic activities, climate change also enhances the dispersal of alien plants outside their natural range (Taylor *et al*., 2012). Their invasion and dominance in new geographic regions induces serious social and ecological impacts (Ojija & Ngimba, 2021; Prass *et al.*, 2022). For instance, they threaten human well–being, biodiversity, pollination, and ecosystem functioning and services (Laizer *et al.,* 2021; Ojija, 2022; Uyi *et al*., 2021). IAPs have been referred to as ecosystem engineers because of the alterations they bring about in the recipient environments (Perkins *et al.,* 2011). In order to guarantee rangeland sustainability, food security, human wellbeing, and overall economic prosperity, it is crucial to stop the spread of AIPs (Ngondya & Munishi, 2021; Ojija & Manyanza, 2021).

In sub–Saharan African countries such as Tanzania, most IAPs are unsafe for human, biodiversity, and ecosystem health (Ojija *et al.,* 2019a, 2019b; Witt *et al.*, 2018). Their invasions are associated with plant community disassembly i.e., they alter the ecosystem structure, as well as farms, grazing lands, and rangeland quality (Ojija *et al.,* 2019a, 2019b). The spread of IAPs is facilitated by their high fecundity, rapid germination, and growth rate (CABI, 2019; Eppinga *et al.*, 2022). *Parthenium hysterophorus* invasion is threatening biodiversity conservation, ecosystems, livestock, and agriculture in Tanzania (Ojija *et al.,* 2019a; Ojija & Manyanza, 2021; Ojija & Ngimba, 2021). Previous research has shown that *P. hysterophorus* decreases the amount of fodder on rangelands, as well as the grazing potential and the capacity to regenerate (Navie *et al.*, 2004). The production of allelochemicals, which inhibit the growth of surrounding coexisting plant species, also displaces indigenous plant species, altering the composition of the vegetative community into communities that are dominated by Parthenium (Foxcroft *et al.,* 2006) Despite the negative impacts associated with IAPs to native plants, limited studies have been conducted to assess the impact of *P. hysterophorus* on native forage species in sub-Saharan Africa, particularly in Tanzania. Similarly, little has work been done in the country to identify dominant co-exiting native plants with *P. hysterophorus* that could be used to suppress the invasive by increasing their density following competition experiments. Therefore, identifying native plant species that co-exist with *P. hysterophorus* is critical for control and management of the invasive (Ammondt & Litton, 2012; Khan *et al*., 2013, 2013; Ngondya & Munishi, 2021). This is because the dominant co-coexisting native plants can be used for the restoration of invaded habitats by maintaining their abundance, density, and/or diversity in the invaded habitats (Richardson *et al*., 2007; Weidlich *et al.*, 2020). The benefit of using dominant co-exiting native plants is that not only they seem to be good competitor with the invasive plants, but also they have minimum negative impacts on the environment compared to exotic species (Khan *et al*., 2013; Ojija & Ngimba, 2021). Hence, there is a need to determine the native forage plant species that could be sowed in rangelands and/or grazing lands to benefit livestock and ecosystem. This may contribute to achieving African Union Agenda 2063 Goals 1, 3, and 4 and the Strategy for controlling IAPs in Africa (2021-2030) (Ngondya & Munishi, 2021).

However, based on our knowledge, there are limited studies in Tanzania that have assessed the dominant co–existing plant species with *P. hysterophorus*, and the impact of *P. hysterophorus* cover on co–occurring selected native forage species. Thus, the specific objectives of the study were to assess (i) the dominant co–existing plant species with *P. hysterophorus*, and (ii) the impact of *P. hysterophorus* cover on the abundance of selected native forage plant species. We hypothesized that (i) non–natives are the dominant plants co-existing with *P. hysterophorus*, and (iii) the abundance of native forage plant species decreases with increasing *P. hysterophorus* cover.

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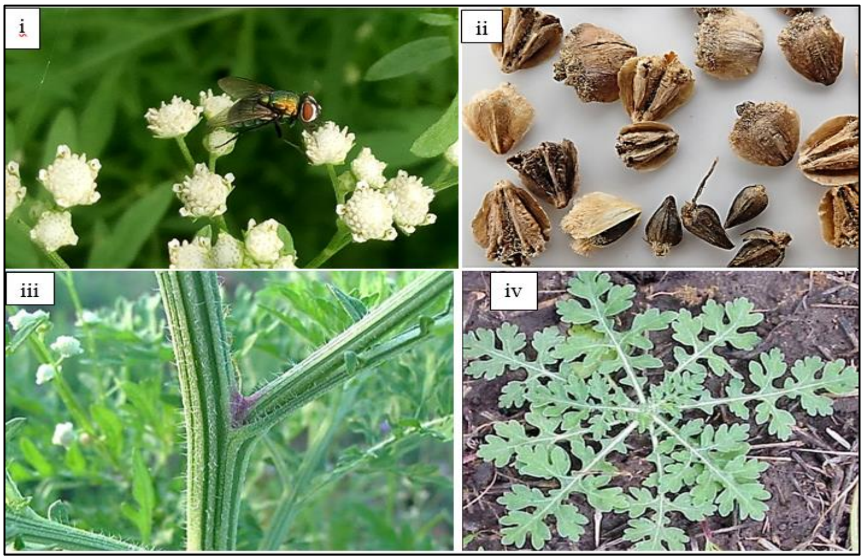
MATERIAL AND METHODS

Characteristics of Study Species

Parthenium hysterophorus invades pastures that have been disturbed, ruined, overgrazed, and places where there is little to no grass cover (Ojija & Manyanza, 2021). It cannot, however, be established in pastures or areas with unaltered natural vegetation. It is an annual herbaceous plant (1.0 to 2.0 m tall) bearing creamy-white flowers (4 to 10 mm in diameter, Fig. 1) (Ojija *et al*., 2019a). It has lobed leaves, a stem that is upright and branches, a deep, robust tap root, and forked root systems (Brunel *et al*., 2014).

Figure 1: (i) flowers, (ii) seeds, (iii) stem, and (iii) rosette of *P. hysterophorus*



Source: (Photo taken by Ojija, 2018)

Parthenium hysterophorus plants typically yield 810 flower heads, 10,000–25,000 seeds, and around 624 million grains per plant (Ojija *et al*., 2019a). The life cycle of the *P. hysterophorus* takes over 150 days to complete and takes around 42 days from seed to mature plant (Kaur *et al*., 2014). Its seeds can survive for four to six years and germinate all year long in the soil. Under favorable circumstances, it can complete 4-5 generations annually (Tanveer *et al*., 2015). For *P. hysterophorus* seed germination, the typical minimum and maximum temperatures are 10 ^{o}C and 25^{o}C, respectively (Brunel et al., 2014) The best soil pH for germinating seeds is between 5.5 and 7.0, but seeds can germinate in a wide pH range (between 2.5 and 10) (Kaur *et al*., 2014).

Field Sites

The fieldwork was carried out in the Arusha and Kilimanjaro regions to determine the impact of *P. hysterophorus* cover on other plant species and the identification of dominant co–existing plant species with the invasive. The study was conducted at KIA (S 3^{o}22.453', E 37^{o}59.822') and Kisongo (S 3^{o}22.172', E 36^{o}38.275') field sites. The mean annual temperature and rainfall in the study sites are 19.5° C and 1361 mm, respectively (Ojija *et al*., 2019a).

Data Collection Method

Assessing the dominant co-existing plants with *P. hysterophorus* and impact on native forage species. Twenty (20) plots of 1 m^2 each, 10 m apart, were established along each of the two 100 m transects at Kisongo and KIA field sites. Prior to species identification, *P. hysterophorus* cover was estimated in each plot based on the ACFOR abundance scale, i.e., abundant: 75–100%, common: 50–75%, frequent: 25–50%, occasional: 5–25%, rare: 1–5% (Stiers *et al*., 2014). Plants were

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identified in each plot at species or morphospecies level. The most dominant plant species co–existing with *P. hysterophorus* were determined based on their relative abundance. The abundance of *Brachiaria reptans*, *Cynodon dactylon, Digitaria milanjiana,* and *Indigofera spicata* was used to estimate the impacts of *P. hysterophorus* cover because they are native forage plant species. Plant abundance was visually estimated in the plots.

Statistical Data Analysis

To investigate the associations between plant species, abundance, and native forage species cover and P. hysterophorus % cover, we performed a Pearson correlation analysis. Levene's test and the Shapiro-Wilk test, respectively, were used to confirm the homogeneity of the variance test and the normality test. All of the tests we ran had a 5% level of significance. Statistical tests were conducted with Origin (2013) version 9.0 SR1.

RESULTS

Dominant Plant Species Co–Occurring with *P. hysterophorus*

The Parthenium-dominated plots contained a total of 45 plant species from 18 different families (Table 1). Overall, non–natives (i.e., *Ageratum conyzoides*, *Datura stramonium*, *Tagetes minuta*, *Argemone mexicana*, *Bidens pilosa, Senna occidentalis*, *Solanum incanum,* and *Xanthium strumarium*) were the dominant plants co–existing with *P. hysterophorus,* except the native *Digitaria milanjiana* (Table 1). They had a high relative abundance compared to other plant species in the studied areas (Table 1).

Table 1: Abundance and species of plants co–occurring with P. hysterophorus at KIA and Kisongo in Arusha and Kilimanjaro regions

Species name	Family	Abundance	Rel. abundance (%)
Conyza bonariensis	Asteraceae	4	0.5
Trichodesma zeylanica	Boraginaceae	18	2.1
Bidens pilosa	Asteraceae	43	5.0
Brachiaria reptans	Poaceae	39	4.5
Setaria verticillata	Poaceae	14	1.6
Tagetes minuta	Asteraceae	46	5.3
Justicia flava	Acanthaceae	6	0.7
Cynodon dactylon	Poaceae	27	3.1
Launaea cornuta	Asteraceae	9	1.0
Gutenbergia cordifolia	Asteraceae	3	0.3
Schkuhria pinnata	Asteraceae	5	0.6
Sphaeranthus suaveolens	Asteraceae	29	3.4
Tribulus terrestris	Zygophyllaceae	13	1.5
Sida rhombifolia	Malvaceae	33	3.8
Oxygonum sinuatum	Polygonaceae	32	3.7
Digitaria milanjiana	Poaceae	39	4.5
Crotalaria sp	Fabaceae	27	3.1
Ipomea mombassana	Convolvulaceae	31	3.6
Indigofera spicata	Fabaceae	21	2.4
Rhynchosia minima	Fabaceae	9	1.0
Pergularia daemia	Asclepiadaceae	6	0.7
Sesbania sesban	Fabaceae	13	1.5
Solanum incanum	Solanaceae	37	4.3
Senna septemtrionalis	Fabaceae	3	0.3
Ipomea sp	Convolvulaceae	24	2.8

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Species name	Family	Abundance	Rel. abundance (%)
Commelina benghalensis	Commelinaceae	11	1.3
Ocimum gratissimum	Lamiaceae	14	1.6
Panicum trichoclada	Gramineae	9	1.0
Leucas grandis	Lamiaceae	22	2.5
Amaranthus hybridus	Amaranthaceae	13	1.5
Lantana camara	Verbenaceae	3	0.3
Alternanthera sessilis	Amaranthaceae	5	0.6
Argemone mexicana	Papaveraceae	39	4.5
Amaranthus spinosus	Amaranthaceae	16	1.8
Setaria homonyma	Poaceae	4	0.5
Galinsoga parviflora	Asteraceae	8	0.9
Datura stramonium	Solanaceae	47	5.4
Leonotis nepetifolia	Lamiaceae	14	1.6
Xanthium strumarium	Asteraceae	36	4.2
Senna occidentalis	Fabaceae	37	4.3
Ageratum conyzoides	Asteraceae	51	5.9
Plectranthus lanuginosus	Lamiaceae	5	0.6

Impact of *P. hysterophorus* Cover On Plant Abundance and Native Forage

According to a correlation analysis, plant species (n = 45, r = -0.889, *P* = 0.043, *Figure 2*) and abundance (n = 865, r = -0.968, *P* = 0.007, *Figure 3*) considerably decreased as *P. hysterophorus* % cover increased. The percent cover of native forage plants, *Brachiaria reptans* (r = -0.922, *P* = 0.026), *Cynodon dactylon* (r = -0.972, *P* = 0.006), *Digitaria milanjiana* (r = -0.938, *P* = 0.018), and *Indigofera spicata* (r = -0.977, *P* = 0.004), also decreased with increasing invasive cover (Fig. 4). *Cynodon dactylon* and *I. spicata* had lower cover compared to other dominant native forage spaces in plots with *P. hysterophorus* cover of > 70%.

Figure 2: Impact of *P. hysterophorus* cover on the number of plant species

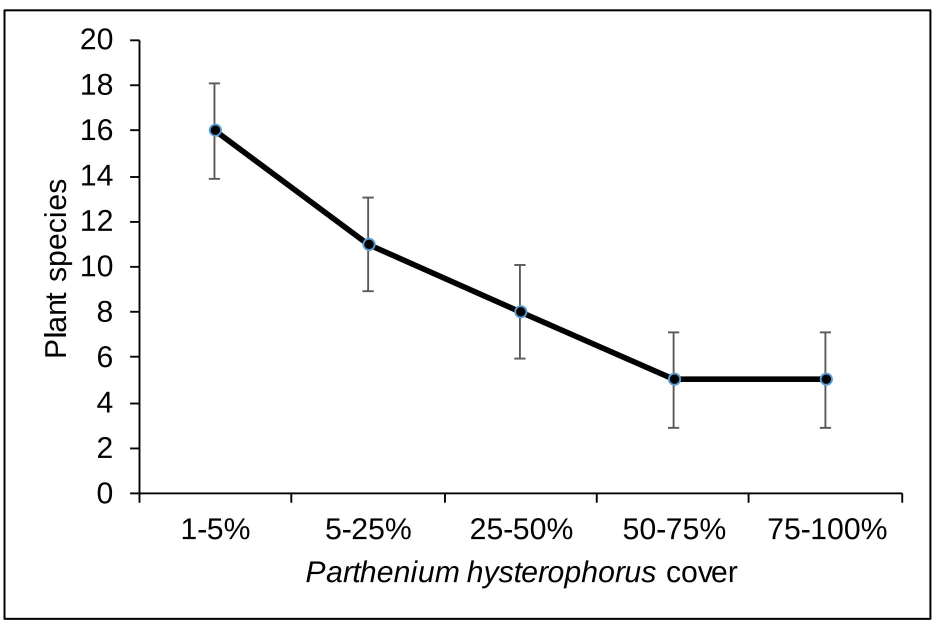

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Figure 3: Impact of *P. hysterophorus* cover on plant abundance

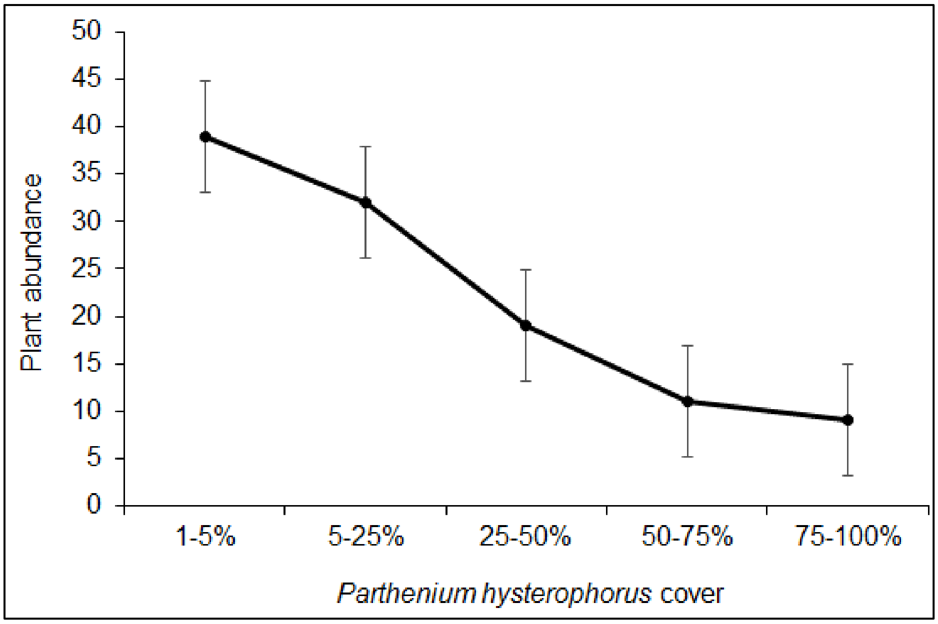
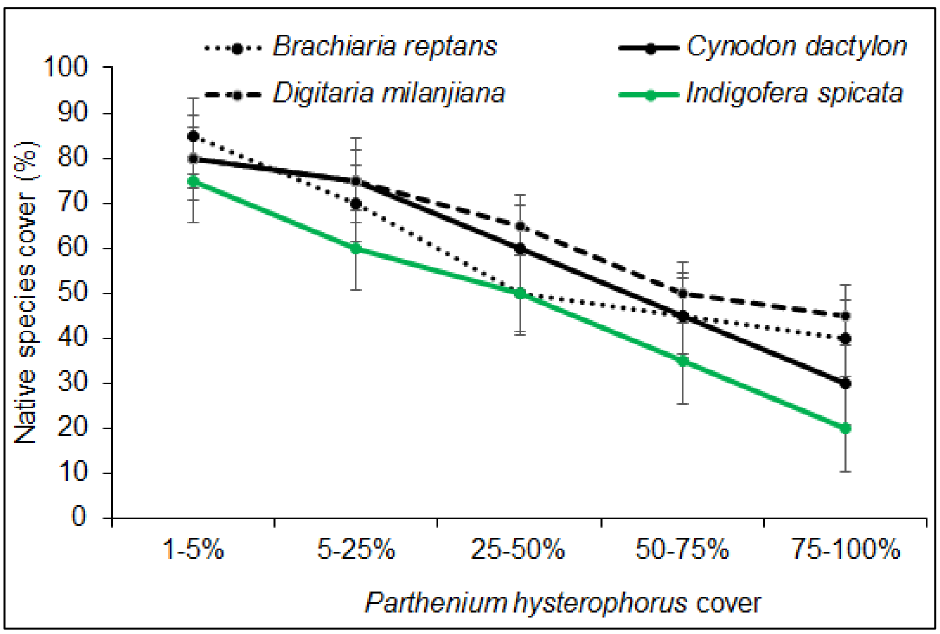


Figure 4: Impact of *P. hysterophorus* cover on selected native forage plant species cover



DISCUSSION

Our results found that some plant species were dominant in *P. hysterophorus* invaded plots. Most of the dominant co-existing plants with *P. hysterophorus* were exotics. They had a high relative abundance compared to native plant species, which indicates that exotic plants are possibly less impacted by the competition and allelopathic effects of *P. hysterophorus*. Furthermore, this shows that exotic plants might equally compete with *P. hysterophorus* for floral visitors, nutrients, space, and water. Overall, plant abundance and species declined in plots with higher *P. hysterophorus* percent cover. For instance, during our survey, we found that the native forage

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plants (*B. reptans*, *C. dactylon*, *D. milanjiana*, and *I. spicata*) percent cover decreased with increasing *P. hysterophorus* percent cover. This highlights the potential consequences of *P. hysterophorus* in reducing forage availability and thus posing negative effects on livestock and wildlife. Hence, our findings provide evidence that native plants are prone to loss from their natural habitats if *P. hysterophorus* invasion cover dominates. As such, *P. hysterophorus* management and control are imperative to prevent its devastating negative effects on the environment.

Moreover, the co–existing concept demonstrates the possibility of suppressing invasive growth through competition with dominant co–existing native plants (Ammondt & Litton, 2012; Ojija & Ngimba, 2021). Previous studies show that by maintaining the abundance and diversity of coexisting native plants, the invasive could be controlled (Ammondt & Litton, 2012). Also, restoration of invaded habitats using dominant co–existing native plants could enhance pollination and ecosystem health (Arathi & Hardin, 2021; Guo *et al*., 2018; Weidlich *et al*., 2020). Therefore, it may be possible to restore P. hysterophorus-invaded habitats using dominant co-existing native plant species because they help maintain ecosystem stability by providing food for livestock and wildlife, facilitating the flow of nutrients within the ecosystem, and preserving soil fertility.

CONCLUSION

The study advances knowledge of how invasive species affect biodiversity and how they can affect forage abundance. With the increasing invasion of *P. hysterophorus* in Tanzanian natural and semi–natural ecosystems, it is expected that more native forage species will decline. This will impact wild animals and the ecosystem beauty of these areas and eventually decrease the attractiveness of national parks to tourism. For the government, management agencies, and other parties involved in management and tourism activities, this could mean a loss of revenue. Generally speaking, this study provides baseline data for future studies to clarify P. hysterophorus' effects on biodiversity preservation.

Limitation of the Study

Time and budgetary constraints limited the study survey; therefore, it suggests additional long-term surveillance of the effects of the invasive on native plants..

CONFLICT OF INTEREST

The author affirms that there were no financial or commercial ties that might be seen as having a potential conflict of interest while the study was carried out.

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