Status of *Ageratina adenophora* invasion in Radhi locality of Trashigang district, Bhutan

Abstract

Ageratina adenophora (Sprengel) King and Robison, commonly known as Mexican devil, is considered as one of the aggressive species, which invades almost all parts of ecosystem. Particularly, people who rear livestock and depends on naturally available fodders has a biggest concern over the invasion of this species. Therefore, this study was conducted to generate knowledge on current status of *A. adenophora invasion* and its potential impact on livestock and fodder species of Radhi Gewog (Village block) under Trashigang district of Bhutan. The study recorded the total of 14 fodder species distributed in both open and undisturbed forest, and *Artemisia* sp. was the most abundant fodder in the sampled site. We learnt that the livestock mainly used the open areas for grazing and browsing, but 87.5% of sampled plots in this area was invaded by the *A. a adenophora*, affecting the growth of fodder species. Due to this reason, a strategic management plans needs to consider the eradicating or controlling the invasion of *A.adenophora* across the country, particularly at grazing sites and places where people depends on livestock for the livelihood.

Keywords: *Artemisia*, *Ageratina adenophora*, Bhutan, fodder, Maxican devil, Radhi Gewog, Trashigang district.

1. INTRODUCTION

The *Ageratina adenophora* (Sprengel) King and Robison, commonly known as Mexican devil, is a perennial flowering plant species in daisy family [1, 2]. It can survive against the diverse environmental condition, easily adapting to new environment, including high dispersal ability, rapid reproduction and growth [3]. The species currently has invaded in almost all the countries [4, 5), including Bhutan [6, 7). This invasion is identified for triggering a severe threat to the environment and ecosystems [8, 9] and also the agriculture and livestock [1]. The species is known to release allelochemicals, that inhibits the growth and establishment of other species [5, 10, 11, 12, 13]. Moreover, it can be expected that, in a long run, it can weaken the resistance ability of ecosystems, thus disrupting the ecosystems and its services.

Most invasive plant species spread quickly over the disturbed areas including the *A. adenophora* [5]. The species mostly emerges rapidly along the roadsides or newly constructed roads and near

water source [14,15] which also implies to Bhutan. Moreover, it is very common in barren land, grassland, and cultivated land, but limited to natural environment of the forested areas [16]. Especially, it is being predicted that the southern belt and agricultural lands of Bhutan poses the highest risk due to *A.adenophora* [7, 17], but the unsustainable management and climate change can drive this species much towards the higher altitude.

The *A. adenophora* is also known in reducing the grazing land and fodders available for the livestock [18]. Moreover, the species are known to be consumed by the livestock, where excessive consumption causes breathing difficulties and also it's dead [19, 20]. This impact is poorly understood due to the lack of systematic studies and limited information, thus calling for intensive research and management planning. This study was intended to generate knowledge on impact of *A. adenophora* on livestock and fodder species of Radhi locality under Trashigang district of Bhutan. The knowledge generated can be used as a lesson to adopt strategic management planning to eradicate and prevent the spread of this species in other parts of the country.

2. MATERIALS AND METHODS

2.1 Study area

This study was carried out at Radhi Gewog (Village block) (91° 45' 13.9752" E; 27° 15' 24.048" N) located under Trashigang district of Bhutan (Figure 1) on January 2021. The area coverage of this village block is 29 km^2, and falls within an altitude range of 1,080 - 3,220m asl. The people residing in this area mainly depend on agriculture and livestock (cattle, horse, goat and sheep) farming for their livelihood, and most villagers' rear atleast one of these domesticated animals. The monthly average temperature of locality varies between 12 degree Celsius to 22 degree Celsius and the average annual rainfall is 1,353 mm, which are optimal climates to maintain the ecological diversity and integrity. Some of the dominant tree species that make up forest at the locality are the *Pinus roxburghii*, *Pinus walliachina*, *Quercus graffithii*, *Castronopsis hystris*, *Symplocus lucida*, *Quercus glauca* and *Cupressus tortulosa*.

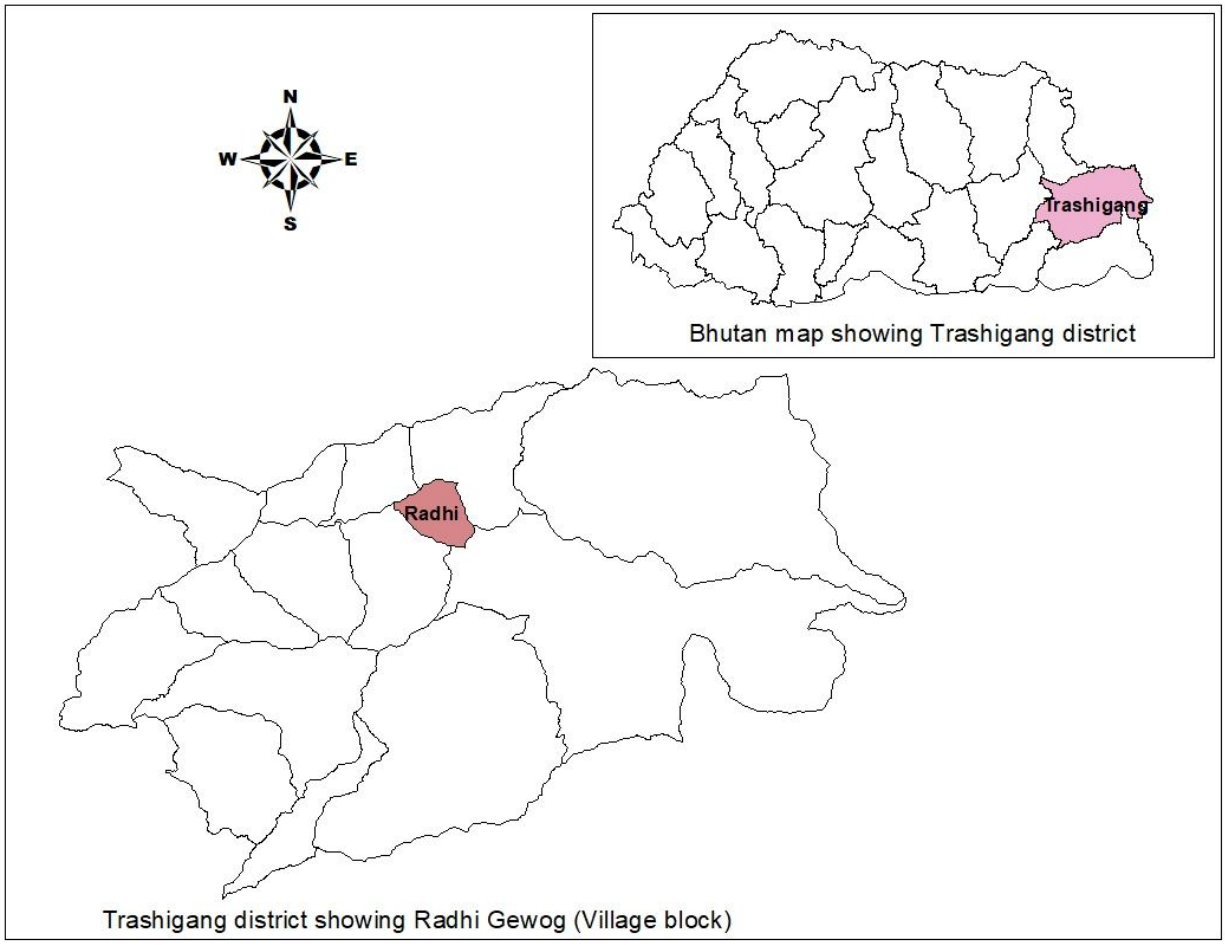

Figure 1: Bhutan map showing the study area

2.2 Data collection method

The *A. adenophora* and fodder species were sampled from $5m^2$ quadrat, where were established equally of 24 numbers each at disturbed and undisturbed forested area. The disturbed areas included open areas, meadows, streamside, and grazing sites which were frequently visited by domesticated animals and humans. The quadrats were laid along the altitudinal ranges between 1300-2700 m asl, maintaining the interval of 50m, but 500m away from the settlements, roads and agricultural land. From each quadrat, the presence/absence and count of individual fodders and *A. adenophora* were recorded to understand its status. The knowledge of fodder species was based on atleast one elderly individual of 25 households, selected based on snowball sampling, who rear domesticated animals for the livelihood, besides agriculture. Moreover, their perception on impact of *A. adenophora* on livestock was also collected to complement the data.

3. RESULTS AND DISCUSSION

The *Ageratina adenophora* was present at 27 of 48 sampled plots between the elevations of 1300m - 2300m asl. In total, the study recorded 776 individuals and most of these individuals were recorded from disturbed areas (21 of 24 plots, 87.5%), substantially reduces in undisturbed forest with thick undercover species, present only in 7 out of 24 plots (21.17%). Moreover, 56% of respondents stated that the *A. adenophora* mainly invades meadows, and rest at streamside (12%), grazing sites (24%), and forest (8%). The population of the species was also known to be increasing over a year, suppressing the growth of other species, and this has also worried the respondents, because the horses, cattle and sheep that consume the species have been causing breathing difficulties, and some even died in the past.

Globally, the *A. adenophora* occurs as low from sea level until as high as above 3000m asl [21, 22]. Usually, the abundance and coverage of species increased with altitude and stabilized at around 2000 m asl [23]. The species is currently absence above 2300m asl in the current study area, but it can be expected that it may expands its range towards higher elevation due to future climate change [24, 25]. Moreover, since the human-disturbed area and grazing area becomes a successful place for the invasion of the most invasive species [26, 27], this may further promote the expansion of *A. adenophora* [28] both within its current habitat range as well as towards the higher altitude, which can disrupt the healthy functioning of ecosystem. Currently, Nepal is one of the countries that is thriving the impact of the *A.adenophora* [29], and Bhutan should consider this as a lesson to prevent future consequences.

Subsequently, the study recorded a total of 14 fodder species, which includes herbs (2 species), grasses (4 species) and trees (7 species), belonging to nine families and comprising the total of 749 individuals (N). Most of these species were found between the elevation range of 1300m to 2700m asl, except the fodder trees, as none recorded from any of sampled plots above 2400m asl. Of all the species, *Artemisia* sp. was the most abundant species (n = 199, RA = 26.57%), and least were *Prunus ceraoides*, *Lindera pulcherrima*, and *Ficus oligodon* with 3 individuals each (RA=0.40%). However, all these species were scarcely distributed, where *Artemisia* sp. was recorded from 14 of 48 plots, being highest, and rest from only 1-5 sampled plots (Table 1).

The *Artemisia sp*., though being important fodder species in the present study area is also reported to be invasive around the globe, occurring in almost all the areas [30]. It has the capability of adapting and colonizing the area in a short range of time dominating over the native species [31]. This might be a reason of its abundance in the present study area, which should be otherwise controlled, so that domesticated animals can have a choices of fodders to obtain various nutrient. Moreover, the least abundant fodder species should be given attention and managed to enhance its survival rate and population.

Table 1: Total count, relative abundance, family and life form of fodder species

Species	Total count (N)	Relative abundance (RA) (%)	Family	Life form
Aconogonum molle	113	15.09	Polygonaceae	Herb
Artemisia sp	199	26.57	Asteraceae	Herb
Elastostema lineotatum	143	19.09	Urticaceae	Herb
Bamboo balcooa	60	8.01	Poaceae	Grass
Borenda grossa	53	7.08	Poaceae	Grass
Bambusa teres	127	16.96	Poaceae	Grass
Pennisetum clandestinum	15	2	Urticaceae	Grass
Salix babyloica	6	0.80	Salicaceae	Tree
Prunus ceraoides	3	0.40	Rosacea	Tree
Quercus glauca	11	1.47	Fagaceae	Tree
Ficus nerrifoila	7	0.93	Moraceae	Tree
Ficus roxbhurghii	6	0.80	Moraceae	Tree
Lindera pulcherrima	3	0.40	Lauraceae	Tree
Ficus oligodon	3	0.40	Moraceae	Tree

Note: $Relative\ abundance\ (RA) = \frac{ni}{N} x\ 100$

4. CONCLUSION

The present study found that the *A.adenophora* affects the abundance and availability of fodder species, and in current study area, more than 50% of the sampled plots has been invaded by this species. The species is currently distributed within the elevation range of 1300m - 2300m asl, but the possibility of expansion within and towards higher elevation has been foreseen, if the natural habitats are being disturbed. The consequences will leads to extinction of native species, disrupt

healthy functioning of ecosystem, and also known to slowly killing the cattle, horses and sheep, when consumed. Therefore, it is necessary that the relevant agencies to consider strategic planning for controlling the invasion of *A.adenophora* across the country, particularly at grazing sites and places where people depends on livestock for the livelihood. Alternatively, plantation of fodder tree species should be considered to protect the forested area, so that it can serves as a natural barrier for the expansion of the *A.adenophora*.

CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the author(s).

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