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Invasiveness Assessment of *Centella asiatica* (L.) Urb., a Medicinal Herb that is Reported as a Major Weed in the Philippines

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ABSTRACT

The medical merits of the traditional herbal medicine *Centella asiatica* (L.) Urb. is generally accepted and established in modern medicine especially in dermatology and cognitive therapy, while numerous ongoing studies are exploring its application in internal medicine. However, it is also reported as a weed in several tropical islands, including the Philippines, where it is a native species. With the increasing popularity of natural remedies, coupled with the concerns of decreasing biodiversity in the country, an increase in intentional cultivation of invasive species is cause for concern. Hence, available literature was explored to assess the invasiveness potential of *C. asiatica* on Philippine ecosystems. It was found that *C. asiatica* growth is favored in the climate of the majority of the country and that the herb can establish itself in varied ecological conditions. However, its weed status may not be due to data showing noxious tendencies but rather an economic perception by people whose cultures do not utilize *C. asiatica* for food or medicinal purposes. Chemical control may be unnecessary with the holistic control suggested, which is based on its biology.

Keywords: *Centella asiatica*, invasive potential, weed reproductive biology, holistic weed management.

INTRODUCTION

Centella asiatica (L.) Urb. is a well-studied medicinal herb that has been chronicled in Asian cultures for thousands of years, and documented as a treatment for a wide range of ailments (Gohil *et al*., 2010). Today, the use of *C. asiatica* extends to the West (Chevallier, 2016) and its chemical properties have been widely investigated over the last century for its application in various branches of medicine. Its most established findings are for its effective applications in dermatology (Bylka *et al*., 2013) and cognitive therapy (Gohil *et al*., 2010), while it continues to drive further studies investigating its promising applications for treating endocrine, cardiovascular, gastrointestinal, immune, and gynecological diseases (Sun, 2020). Because of the popularity of *C. asiatica* both in ancient and modern times, and over such a wide breadth of applications, the motivation behind its cultivation is apparent.

In the Philippines, Centella asiatica has been recognized as a medicinal herb for well over a century. It appears in T. H. Pardo de Tavera's Plantas Medicinales de Filipinas, first published in April 1892. A translation of the text by J. B. Thomas in 1907 implies the accepted use of the herb as a diuretic, saying, "In the Philippines, the decoction of the leaves is given as a purge." While the specific locations of Pardo de Tavera's documented use are not specified, this documentation provides enough reason to believe that *C. asiatica* has been cultivated in the Philippines since the Spanish period or earlier.

Concurrent with its documentation as a medicinal plant, Madulid *et al*. (2017) indicate *Centella asiatica* as a pantropical weed. It is also listed by Moody *et al*. (2014) as a major weed in the Philippines, common in areas of dryland field crops.

These seemingly paradoxical perceptions of its importance as found in available literature serve as the rationale for our inquiry into the biology of *Centella asiatica*. The willful cultivation of a potentially invasive plant may have negative long-term repercussions on the ecosystems that provide conditions for it to thrive. With the resurging interest in natural remedies, it is worth investigating the biology and ecology of *C. asiatica*, to help provide people with educated and responsible cultivation practices.

Here are the objectives of this review:

1. To understand the morphology, reproductive biology, and ecology of *Centella asiatica* aimed at understanding.
    a. The potential effect of *C. asiatica* encroachment on the ecosystems it inhabits.
    b. The implication on the livelihoods dependent on these ecosystems.
2. To design a holistic control strategy that is specifically based on its biology, aimed at:

a. Educating gardeners about the proper cultivation of *C. asiatica*.
b. Demonstrating that herbicide use may be avoided in areas where its growth may not be desirable.

MATERIALS AND METHODS

Owing to its application in medicine, its phytochemical characteristics are well-studied, helping to establish its economic importance. Findings from such relevant studies are used as reference material in appreciating its significance as a crop. By contrast, its weed potential seems to be sparsely documented.

To establish its weed potential, a literature review was conducted to obtain information that will allow us to:
1. Examine the morphology, reproductive biology, and ecology of *Centella asiatica* to:
   a. Identify the propagation mechanisms of *C. asiatica*.
   b. Determine its characteristics that give clues to its invasive potential, as guided by available literature about its growth and reproduction.
2. Deduce the manners in which its unwanted growth may be prevented based on its biology and ecology

RESULTS AND DISCUSSION

A. Morphology, Reproductive Biology, and Ecology

Centella asiatica is a creeping perennial herb, with long taproots, and soft, slender stems which develop into runners that root at the nodes. Its leaves are orbicular to reniform, petiolate, with crenate to dentate margins, rounded apices, subcordate to cordate bases, and some with a deep basal sinus. The inflorescences are axillary umbels with 3–4 white or rose-tinged flowers, usually 1 cm long, ovate and inconspicuous. Fruits are 3–4 mm across, round to oval, with two seeds per fruit. It propagates by seeds and runners. (Figures 1–4) (Moody, 2014).

Centella asiatica can be found in the Caucasus region, tropical & subtropical Old World to New Zealand, and the Southwest Pacific area. It is native to the Philippine islands (Kew Science, 2021) and can be observed at low to medium altitudes, on residential lawns, field crops, damp waste places, abandoned fields, and rice paddies (Madulid *et al*., 2017).

Plant yields from stem cuttings vs. seedlings show that the population of *C. asiatica* raised from stem cuttings

Figure 1. *Centella asiatica* population on the author's lawn.

Figure 2. Close-up of a ramet showing its runners.

Figure 3. A section of one individual, showing 4 ramets with fruits.

Figure 4. Magnified fruit of *Centella asiatica* (40x).

is more competitive than those that developed from seedlings (Wankar and Tripathi, 1990). This is supported by Singh and Singh in 2002, with results that show substantial variations in growth parameters that could be attributed to the proportions of ramets to genets in the populations studied. "Total biomass, leaf area, and numbers of leaves, stolons, daughter ramets, and seeds were higher for ramets at all proportions. Relative growth rate and leaf area ratio were also higher for ramets, while the net assimilation rate was higher for seedlings. Net assimilation rate and crude reproductive effort were enhanced due to competition in both the ramets and seedlings." They also found that the growth performance per pot was more favorable in monoculture compared to mixed culture. The ramets' yield and ability to compete were not because of any starting benefit of superior biomass; relative total yield indicated that both types of populations strove for similar resources. "In nature, the ramets play a greater role in population maintenance of *C. asiatica*." (Singh and Singh, 2002).

Soil and fertilizer requirements of *Centella asiatica* were studied by Devkota and Jha in Nepal. Based on growth parameters such as the number of leaves per ramet, petiole length, specific leaf area, number of primary branches, and plant biomass, their findings indicated that *C. asiatica* favors sandy loam rather than clayey soil (2009) and a 50/50 combination of organic and inorganic manuring (2013).

In another study, Devkota and Jha (2010) examined growth patterns and yield of *Centella asiatica* plants in varying levels of lighting conditions: 0% (full sun), and shading of 30%, 50%, and 70%. Their data suggested that plants grown under 30% shading developed higher plant biomass above ground but root systems showed higher dry biomass under full sun conditions.

In an earlier study in India, the effects of light, soil moisture, and soil texture on the growth and reproductive allocation of *Centella asiatica* were investigated by Wankhar and Tripathi (1990). Their results showed that plants produced a greater number of leaves, number of ramets, larger leaf area, and more dry matter under high light compared to low light (50% shading) conditions. Sandy loam soil and high moisture promoted growth, especially under high light. "Proportional allocation to clonal growth and sexual reproduction was greater under high light, while the allocation to the mother rosette was greater when the plants were grown under shade. The differences in dry matter allocation due to soil texture, soil moisture, and stem cutting size were significant. Of all the factors studied, light seemed to be the most significant factor in determining the growth and reproductive allocation of *C. asiatica*." (Wankhar and Tripathi, 1990). Findings on the Reproductive Biology and Ecology of *Centella asiatica* can be found in Table 1.

These sources agree on the same conditions that favor the growth of *Centella asiatica.* In general, the plant thrives in tropical and subtropical climates, under partly shady, moist conditions with sandy loam soil and a combination of nutrient sources that are immediately available as well as a more sustained source over a longer period. These conditions are met in a cultivated field or lawn in Type II, III, and IV Philippine climates, where dry seasons are brief, if at all pronounced (PAGASA, 2021). The Philippines only has 4 climate types and *C. asiatica* growth is favored in 3 out of these 4, meaning that its growing conditions are met in the majority of the Philippine islands.

Table 1. Findings on the Reproductive Biology and Ecology of *Centella asiatica.*

Aspects	Characteristics
Habitat	Low to medium altitudes, on residential lawns, field crops, damp waste places, abandoned fields, and rice paddies (Madulid *et al.*, 2017)
Reproductive biology	• Propagation by seeds and runners (Moody, 2014) • Plants from stem cuttings are more competitive than those that developed from seedlings (Wankar & Tripathi, 1990)
Soil and fertility requirement	Sandy loam rather than clayey soil and a 50/50 combination of organic and inorganic manuring (Devkota & Jha, 2009, 2013)
Moisture requirement	High moisture promoted growth (Wankhar & Tripathi, 1990)
Light requirement	• Plants produced a greater number of leaves, number of ramets, larger leaf area, and more dry matter under high light compared to low light (50% shading) conditions (Wankar & Tripathi, 1990) • Plants grown under 30% shading developed higher plant biomass above ground, but root systems showed higher dry biomass under full sun conditions (Devkota & Jha, 2010)

Since the maintenance of *Centella asiatica* populations depends largely on the vigor of its ramets, we can infer that once a genet establishes itself in ideal conditions, controlling *C. asiatica* populations will depend on the thorough removal of its ramets. Its taproot system poses an advantage towards its persistence, since long and slender roots may contribute to incomplete hand-pulling

B. Ethnomedicinal Value and Invasive Potential

Traditional uses for *Centella asiatica* in the Philippines are for medicine, prepared in decoctions for respiratory ailments and measles, poultices as counterirritants, as tea or eaten raw for rejuvenation and mental stimulation. Modern preparations include using fresh leaves in salads and dried leaves as tea. The use of *C. asiatica* leaves as medicine is officially documented in Dutch, French, Mexican, Spanish, Venezuelan, and Indian Pharmacopoeias. The use of stems and leaves is officially documented in the ancient Chinese Materia Medica. (Galvez Tan and Galvez Tan, 2017) In the West, *C. asiatica* leaves are used as a culinary herb and as a medicine (Cook, 1996 as cited in Lansdown, 2019). It is used raw or cooked and eaten with rice as a tonic or a medicament for skin diseases, including leprosy (Hedge and Lamond, 1992 as cited in Lansdown, 2019). It is an important herb ("ji xue cao") of traditional Chinese medicine (Chen *et al*., 2011) and is important in Indian Ayurvedic medicine (Lansdown, 2019).

The medicinal properties of *Centella asiatica* are well-studied and established, and the interest in its application as a treatment for many diseases remains unabated in the last several decades. There are numerous phytochemical and medical studies, but in recent years, concern has been expressed over the over-harvesting of *C. asiatica.* "Pharmaceutical companies largely depend upon material procured from naturally occurring stands which are being depleted rapidly, raising concern about the possible extinction of the species and providing justification for the development of in vitro propagation techniques for this crop." (Patra *et al*., 1997). As of 2004, *C. asiatica* is considered as a "vulnerable species" in the Red Data Book of plant species of Iran, having a definitely exclusive habitat around the Anzali lagoon (Taghizadeh *et al*., 2004).

The same concerns about *Centella asiatica* populations being compromised due to the demands arising from its clinical applications were expressed by Zhang *et al*. (2012). They, too, believe that if no action is taken towards its conservation, *C. asiatica* will become extinct. They propose the combined use of chemical

and genetic diversity data in identifying medicinal plants to provide a useful guide for their efficient utilization, conservation, breeding, and management of good agricultural and collection practices. In their 2012 study, they found populations of *C. asiatica* with high genetic diversity in 3 sites in China, and propose that these populations be prioritized for conservation and as a source for establishing a cultivated population. They found that the populations in these 3 sites have the target chemotypes that may contain active components that are sought after in medical applications. (Zhang *et al*., 2012) In India, a rapid micropropagation protocol was developed by Thangapandian, Devi and Theresa (2012) for the conservation and mass multiplication of *Centella asiatica* to meet the pharmaceutical demand for the herb. They found that the combination of cytokinin with auxin showed significantly higher shoot multiplication within a month. (Thangapandian, Devi and Theresa, 2012) Expressing the same concerns over *C. asiatica* being at risk of extinction, Alagumanian, Jahirhussain, and Rao (2015) developed a culture protocol to enable the harvest of more than 25,000 plantlets within 160 days starting from a single shoot tip explant.

In light of the objectives of this review, it is important to note that even plants of economic usefulness can cause significant problems when grown in conditions that are too favorable. Wersal and Madsen (2012) make a point in the example of sago pondweed, a beneficial native plant in freshwater lakes and ponds, but can be a severely problematic weed in irrigation canals worldwide. Another example is the water caltrop or water chestnut, a food crop in Asia and some European countries, but is a severe weed problem in other parts of the world (Wersal and Madsen, 2012).

Centella asiatica is a member of Apiaceae, a large family consisting of more than 300 genera worldwide, including important crops like carrot, celery, dill, coriander, parsley, *etc*., as well as some plants considered as weeds in some places such as fennel and poison hemlock. (Bell, 2014) According to the IUCN report for the species, *C. asiatica* "is often reported as a weed but is probably not very troublesome". It is reportedly grown as ground cover since it has a significant capacity for preventing soil erosion. This IUCN report maintains that "there are no known significant past, ongoing or future threats to this species. There are no conservation measures in place for this species and none needed." (Lansdown, 2019). Moreover, a study of 16 accessions of *C. asiatica* from different locations in India found the samples to exhibit significant variation in the color, shape, and size of vegetative and floral parts, showing the existence of 2 distinct morphotypes in *C. asiatica*. The authors Mathur, Sharma and Kumar (2003) hypothesized that its genetic variability is the reason for the plant's ability to adapt successfully to a wide range of ecological conditions. According to the CABI Invasive Species Compendium datasheet, *C. asiatica* can proliferate to form a closely-packed ground cover, which may not always be welcome in all situations. It is documented as being invasive in several islands in the Pacific, classed as High Risk (score 7) by PIER (2014), "but the situations in which it is causing problems are not clear. It is not especially competitive in crops but may affect wild vegetation and biodiversity." C. asiatica is also listed as invasive in the Dongting Lake wetlands, Hunan province, China (Hou *et al*., 2011)." (CABI, 2021). Perceptions of *Centella asiatica* as either a weed or a vulnerable species can be found in Table 2.

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As regards to its impact on agriculture in the Philippines, *Centella asiatica* has been reported as a weed in rice paddies. (CABI, 2021) The country's leading crops are rice, maize, sugarcane, coconut, banana, mango, pineapple, cassava, coffee, sweet potato and eggplant. In terms of harvest area, the most extensively grown crops are rice, coconut, maize, sugarcane, banana, cassava, coffee, mango, sweet potato, and Manila hemp (Altoveros and Borromeo, 2006). While literature may imply that *C. asiatica* only affects rice, that is, only one out of many major Philippine crops, *C. asiatica* has been classified as a mesophyte, or a plant that only needs a moderate amount of water, in Laos (Kosaka *et al*., 2013). As already mentioned, C. asiatica has the ability to adapt to a range of ecological conditions (Mathur, Sharma and Kumar, 2003), so the potential is present for its encroachment on other major crops of the Philippines. *Centella asiatica* has also been reported to be a host of *Xanthomonas campestris* pv. campestris. This pathogen occurred epiphytically and without symptoms on the weed *C. asiatica* in Bangalore, India. "Isolates were pathogenic to different cruciferous hosts. Isolates from cauliflower, centella, and radish were able to survive and multiply on *C. asiatica* leaves. It is concluded that this weed may play an important role in the disease cycle of black rot of crucifers." (Kishun and Chand, 1988) This indicates that *C. asiatica* can be problematic in cruciferous vegetable crops, like bok choy, broccoli, cauliflower, cabbage, and some green leafy vegetables, many of which are grown in upland farms and home gardens in the Philippines.

C. Weed Potential and Control

The literature reviewed here, when taken collectively, paints a picture of mixed perceptions towards *Centella asiatica*. In areas where the use of the herb is related to ancient cultural practices, such as Ayurveda and

Table 2. Perceptions of *Centella asiatica* as either a weed or a vulnerable species.

Place	Perception	Source
India	Concern is expressed over the possible extinction of the species	Patra *et al*., 1997
Iran	Considered as a "vulnerable species"	Taghizadeh *et al*., 2004
China	Invasive in the Dongting Lake wetlands, Hunan province, China	Hou *et al*., 2011
China	Concern is expressed over the possible extinction of the species	Zhang *et al*., 2012
India	There is a need for conservation and mass propagation	Thangapandian, Devi & Theresa, 2012
India	Species is at risk of extinction	Alagumanian, Jahirhussain, and Rao, 2015
unspecified	Species "is often reported as a weed but is probably not very troublesome" and that "there are no known significant past, ongoing or future threats to this species. There are no conservation measures in place for this species and none needed."	IUCN (Lansdown, 2019)
Australia	Invasive in Lord Howe Island and Norfolk Islands	PIER, 2021
Pacific islands	Invasive in Kosrae Island and Pohnpei Islands of the Federated States of Micronesia, about 15 islands of French Polynesia, the Ralik and Ratak Chain of the Marshall Islands, Niue, Wallis Island	PIER, 2021
United States	Invasive in 6 major islands of the State of Hawaii	PIER, 2021
British Indian Ocean Territory	Invasive in the Chagos Archipelago	PIER, 2021
East Africa	Invasive in some islands of the	PIER, 2021

traditional Chinese medicine, there seems to be a tendency for concern over the maintenance of *C. asiatica* populations, and efforts to create protocols for maintaining natural stands and designing sustained cultivation. By contrast, the US Forest Service's website on "Pacific Island Ecosystems at Risk" lists *C. asiatica* as Invasive in Lord Howe Island and Norfolk Islands in Australia, Kosrae Island and Pohnpei Islands of the Federated States of Micronesia, about 15 islands of French Polynesia, 6 major islands of the State of Hawaii, the Ralik and Ratak Chain of the Marshall Islands, Niue, Wallis Island, the Chagos Archipelago and some islands of the Seychelles (PIER, 2021). These islands are mainly of Christian and ethnic religious affiliations, whereas Ayurveda is rooted in Hinduism, and traditional Chinese medicine is influenced by Confucianism and Taoism. It is helpful to recall the classic definition of a weed, which is "a plant growing where it is not desired, or a plant out of place—some plant that, according to human criteria, is undesirable." (Monaco *et al*., 2002). In the case of *C. asiatica*, it may be worth investigating the criteria by which the herb is reported as undesirable. Is the herb is listed as invasive in the cited locations based on ecological data, or from reports based on the preferred land use by human inhabitants? Both the IUCN and CABI reports indicate that *C. asiatica* is not particularly troublesome or competitive. Despite having been in cultivation for centuries over a wide area of distribution, *C. asiatica* is not on the list of the world's worst weeds (Holm and Herberger, 1969 as cited in Chandrasena and Rao, 2017).

Foraging, specifically uprooting, is the means of mechanical and cultural control employed for the abundance of *C. asiatica* on levees in Laos (Kosaka *et al*., 2013). Careful disposal is recommended for the waste from gardens or plantations where the plant has been mechanically removed. In terms of chemical control, it is reported to be susceptible to glyphosate (Tsai *et al*., 1987) and to diuron, linuron, and atrazine (Crabtree, 1963). Nagarjuna Fertilizers and Chemicals in India recommends control using 2,4-D although Rochecouste and Vaughan (1963) reported it as resistant to MCPA and 2,4-D in Mauritius; other sources have cited moderate susceptibility to these and other growth-regulating herbicides (CABI, 2021).

Livelihoods depending on moist or damp arable land in the Philippines, such as irrigation dikes of rice plantations, and fields for growing sweet potatoes, among others, are the most susceptible to problems resulting from unwanted population growth of *Centella asiatica*. When the yield is at risk in these crops, holistic control may be achieved by targeting the complete uprooting of ramets. This mechanical control should preferably be done before they have the chance to flower and for seeds to set, or more importantly, right before the dry season so that the physical damage combined with the loss of moisture and increased light intensity will serve to reduce the chance of survival for any taproot remnants.

CONCLUSION

Literature suggests that *Centella asiatica* has morphological characteristics and genetic advantages that may support its unaided proliferation in favorable environments and survival in varied ecological conditions in the tropics. While it can reproduce via seeds and runners, its population maintenance depends mainly on the vigor of ramets. From the trends of invasiveness found, it seems that *C. asiatica* may pose a risk to crop yield and biodiversity in tropical wetland areas populated by human populations whose cultures do not utilize the herb for food or medicinal purposes.

Given that *C. asiatica* favors moist and slightly shady conditions, the main recommendation for holistic control in areas where it is unwanted is by the mechanical removal of ramets before maturity, and/or timed with the onset of the dry season. This specific timing will serve to prevent taproot recovery by utilizing the natural conditions of drought, which is an unfavorable condition for *C. asiatica*. As there is not enough information supporting the noxious competitiveness of *C. asiatica*, it is strongly suggested that mechanical control first be exhausted before resorting to chemical means.

Where its growth may be wanted in controlled amounts, it is recommended that *C. asiatica* be grown in pots and trimmed regularly. Disposal of any unused parts should be done with conscious effort for these plant parts to not end up where they will have the opportunity to grow. Amid long-standing concerns of extinction in areas where *C. asiatica* is utilized on an industrial scale, an alternative means of control may be to investigate the opportunity for invasive natural stands to be harvested, processed, and transported to locations of these said industries. This is an opportunity for livelihood in localities where *C. asiatica* is considered invasive. The economic advantages would be helpful with transitioning the local mindset in these communities, towards a paradigm shift that includes weeds as a part of their means of living, at the same time supporting a healthier ecosystem.

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