Indian Journal of Weed Science **51**(2): 101–105, 2019

Print ISSN 0253-8040 Online ISSN 0974-8164

Potentials of water hyacinth as livestock feed in Sri Lanka

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Article information

DOI: 10.5958/0974-8164.2019.00024.8

Type of article: Review article

Received: 1 February 2019
Revised : 2 June 2019
Accepted: 4 June 2019

Key words
Eichhornia crassipes

Invasive weed

Livestock feeds

Weeds

ABSTRACT

Eichhornia crassipes or universally known as Water hyacinth (WH) is considered as one of the noxious and invasive plants with a high growth rate and vigorous reproductive capacity. Due to these characteristics, this plant causes severe ecological, economic and social problems in many tropical and subtropical countries. Currently, many countries like India, China, Vietnam *etc*., convert this aquatic invasive plant into a beneficial plant to solve serious environmental problems. WH is an excellent source in absorbing nutrients and pollutants from eutrophic/polluted waters. Moreover, WH biomass is used to produce bio-energy, feed and fertilizers. This review discusses the potential of using WH as a livestock feed in Sri Lanka. Sri Lanka is an agricultural country and livestock plays a major role in the society. The non-availability of quality pasture/fodder and shortage of improved pasture/fodder have been identified as one of the major causes for the poor production of milk and meat. But WH has been successfully utilized over the decades as a livestock feed by other countries for ruminants, swine, ducks, geese and fish due to its high crude protein content and progressive growth. Along with the relevant treatments and proper inclusion level to the main ration, this plant is a feasible alternative to rice straw and other low-quality roughages. WH shows an island-wide distribution in Sri Lanka inhabiting freshwater bodies such as tanks, canals, marshes, ponds *etc*. There is a greater opportunity of utilizing this plant to reduce the feed shortage in Sri Lanka ton livestock. Apart from biological, chemical and mechanical control methods, utilizing water hyacinth as a livestock feed is one of the better approaches out of many productive ways of controlling the growth of this plant.

INTRODUCTION

Over the centuries, water hyacinth (*Eichhornia crassipes*) has altered from a beautiful ornamental plant to an invasive alien species that negatively impacted natural aquatic systems (Yan and Guo 2017). Currently WH causes severe complications in at least 62 countries in the regions between 40° N and 45° S (Yan and Guo 2017) and already naturalized in Central America, Africa, Asia, Australia and New Zealand (Ramey 2001). Moreover, this plant has made severe complications such as obstructing the water transportation, providing habitat for disease vectors, reducing biodiversity and obstructing the fishing activities (Ndimele *et al.* 2011). Tham (2016) revealed that all tropical and sub-tropical countries have been infested with *Eichhornia crassipes* and is considered as one of the world's most invasive aquatic plants. Water hyacinth (WH) shows an island-wide distribution in Sri Lanka inhabiting freshwater bodies such as tanks, canals, marshes, ponds, *etc*. (Bambaradeniya 2002).

WH belongs to Family Pontederiaceae is a free floating aquatic plant. It forms two distinct canopies such as leaf canopies above the water and root canopies below the water surface (Downing-Kunz and Stacey 2012). Roots, rhizomes, leaves, inflorescences, stolons and first clusters are the main constituents of a mature WH plant (Penfound and Earle 1948). WH petioles may grow up to 60 cm long and bear flowers while stolons grow horizontally (about 10 cm) and produce new plants from the terminal buds (Parsons and Cuthbertson 2001). To enable the floating of the plant in water is facilitated by the leaf stalks with bladder-like swellings consisting of large air cells (Parsons and Cuthbertson 2001). WH have mauve coloured six petals flowers (Tham 2012) with massive fibrous root system (Tham 2012) which are able to absorb the nutrient even in a low nutrient water body (Xie and Yu 2003).

Livestock plays an immense role in Sri Lankan agriculture. The agriculture sector's contribution to the National Gross Domestic Production (GDP) had

been reduced to 7.9% in 2015 (Central Bank of Sri Lanka 2015) and the contribution of the livestock sector is recorded as 0.6% to the National GDP (Livestock Statistical Bulletin 2015). According to the Department of Census and Statistics (2017), Sri Lanka had 21.2 million chicken, 1.0 million cattle, and 0.3 million buffaloes followed by swine (0.1 million), goats/sheeps (0.23 million), and ducks (0.01 million) as the main livestock species in 2017.

In a global context, the current status of the livestock sector in Sri Lanka is performing underneath the desired expectations due to many reasons. The non-availability of quality pasture/ fodder and shortage of improved grass (pasture seeds) and lands for grass cultivation has been considered to be one of the major bottlenecks in livestock production in Sri Lanka (Houwers *et al.*2015). Perera and Jayasooriya (2008) revealed that seasonal scarcities of green fodder and unbearable cost of concentrates are the main reasons for hindering the growth of the dairy sector in Sri Lanka. Further, they found that the quality and quantity of available forage also fluctuates due to highly seasonal rainfall in many parts of the country affecting the milk yield and lactation length of both cattle and buffalo. Therefore, it is vital to adopt a system where we can obtain fodder and other feed sources for an annual cycle rather than dry and wet season feeding.

Water hyacinth invasion in Sri Lanka

In 1904, the WH was introduced in Sri Lanka as an ornamental aquatic plant, however the plant was distributed in water bodies profusely and threatening the natural aquatic ecosystems in Sri Lanka (Room and Fernando 1992). WH was considered as a prohibited weed in 1909, which was incorporated under the Plant Protection Act in 1924 (FAO 2018). Perera and Dahanayake (2015) revealed that WH and Salvinia *(Salvinia molesta*) profusely dominating in rural and urban eutrophic waterways in Sri Lanka. Sri Lanka is an agricultural country, therefore, irrigation in the dry period is strictly relying on the small tanks and reservoirs. Due to its excessive growth, vigorous reproductive capacity it considerably reduce the productivity of inland water bodies and increase the cost for regular maintenance of reservoirs, irrigation networks, lakes and rivers as well. Moreover, decaying the biomass of WH leads to deteriorate the water quality and aquatic life. The excessive surface covering by water hyacinth of water reservoirs limit the sunlight penetration and decrease the contact with air which leads to decrease the dissolved oxygen concentration which badly affect inland fisheries and aquatic biodiversity. Bambaradeniya (2002) reported that dense mats of WH and *Salvinia* directly inclined by the sedimentation on a greater scale. This cause reduction of water through evapotranspiration also from the reservoirs and converted the wetlands into terrestrial habitats. Bambaradeniya (2002) was of the opinion that letting these aquatic invasive plants established in water ecosystem will reduce and narrow down the native biological diversity.

Chemical composition of water hyacinth

Fresh WH contains about 90% water and 15-20% solid materials (Ndimele *et al*. 2011). Further Ndimele *et al.* (2011) reported that on a dry weight basis, the weed contains about 23-25% protein-related matter. Men *et al.* (2006) revealed that higher the proportion of protein can be found in immature leaves and petioles of the WH than in mature plants. Essential amino acids like glutamine, asparagine and leucine are rich in leaves of WH (Virabalin *et al.*1993) as well. Several studies revealed that the chemical composition of WH varies with season, habitat and fraction of the weed (Poddar *et al*. 1981, Tucker *et al.*1981; Abdelhamid 1991). According to Men *et al.* (2006) percentages of dry matter, crude protein, crude fibre and ash content of water hyacinth were 6.8±0.76,18.6±0.71, 21.4±0.85 and 16.7±1.95, respectively. He reported that the metabolic energy of fresh WH was 2000 kcal/kg. WH is also considered as a carrier of heavy metals such as iron, magnesium and zinc, due to which this weed is used for phytoremediation (Ndimele 2003).

Feed for ruminants

Countries like China, India and Vietnam were able to convert WH as a resource with various kinds of applications. Usage as a source of biogas, animal feed and bio fertilizers are commonly found applications of WH (Bagnal *et al.* 1974, Shiralipour and Smith 1984). Many scientists had conducted experiments to utilize WH as animal feed for cattle, sheep, geese, pigs, *etc*. either in silage form or fresh form. This plant can be utilized to overcome the feed shortage in Sri Lankan livestock due to its high crude protein content and progressive growth along with the relevant treatments. Not only as a livestock feed, but in some countries WH is also used as a vegetable for humans as well. Nguyen (1996) reported that WH flowers are used as a food source in Vietnam.

Due to its high levels of cellulose and hemicellulose, Mukherjee and Nandi (2004) suggested the possibility of using it as a feed for ruminants. Eldin (1992) mentioned that the minimum amount of crude protein content in fodder for ruminants should be 9%. Aboud *et al.* (2005) found that leaves and shoots of WH contained 18% of crude protein which can be

utilized for the young or lactating ruminants, feeding as fresh and as a sole diet can cause severe digestive problems to ruminants. Bolenz *et al.* (1990) revealed that due to the presence of intercellular spaces filled with air in WH and soaking up rumen juices inside their intercellular spaces while digesting, leads to excessive water consumption by the ruminants. Moreover, the tissues of the digestive tract can be damaged by the microscopic sharp needles present in the WH. Further, these needles are formed of calcium oxalate,which discourages the feed intake and causes mouth irritation in livestock. Abdelhamid and Gabr (1991) reported that if WH is offered as a sole diet to the ruminants, the death can be occurred by tetany due to the changes in blood profile in severe cases. But these problems can be eliminated by several treatments. Chopping the WH into fine pieces to remove the air in the tissues to eliminate the growth of aerobic moulds during the fermentation and washing the bagasse with acid to eliminate acid-soluble calcium oxalate after separating the soluble tissue components (juice) by pressing and centrifuging one of the methods to make it utilizable (Bolenz *et al.* 1990). But the acids wash process replaced by the fermentation (Yan and Guo 2017).

According to the Paddy statistic (2014/2015) by the Department of Census and Statistics in Sri Lanka, only 3% of total rice straw production is used as a livestock feed. But, under currently practiced feeding systems at small farms in Sri Lanka rice straw is not pre-treated for improving the feeding value of straw. Tham and Uden (2013) revealed that ensiled WH had >3 times higher protein content and 24% lower neutral detergent fibre than rice straw and suggested that ensiled WH is more favourable than rice straw to animals due to this reason. Further, they reported that formulated WH can be a good feed for cattle with the highest digestibility of 72% for organic matter, 75% for crude protein, 62% for neutral detergent fibre and 49% for acid detergent fibre as well. Baldwin *et al.* (1974) found that cattle immediately accepted the ensiled WH after gradual adaptation. This suggests that with the proper ensiling of WH it can be replaced as feed material to ruminants. Sunday (2002) recommended the utilization of sun-dried WH biomass at 40% of goat feed. Abdelhamid and Gabr (1991) suggested that using WH biomass as roughage for ruminants, crude protein content of 200 g/kg dry matter can be obtained. Sunday (2002) reported that 40% sun-dried WH inclusion was greater than the efficiencies of goats fed with 30% sun-dried WH inclusion. Moreover, the mean final weights of the goats fed with 40% sun-dried WH were significantly higher ($P>0.05$) than the similar ($P>0.05$) weights of goats which fed 30% sundried WH inclusion. Hence utilization of sun-dried WH by growing goats up to 40% dietary level of inclusion is beneficial. Tag EI-Din (1992) revealed that average daily weight gain of sheep can be greatly reduced by providing WH as a sole diet, however substituting the bean straw up to 30% with WH didn't affect the growth rate of sheep. WH also had been utilized as an ensiled product for ruminants. Tham and Uden (2013) tested different additives (molasses, rice bran, inoculants of fermented vegetable juice and their combinations) with WH biomass for silage production. Agarwala (1988) reported that incorporation of molasses, rice straw and urea with WH silage, forms a palatable cattle feed fulfilling the adequate amount of protein need to calves. Byron *et al.* (1975) suggested to add acids adequately to obtain the quality silage. WH silage diet produced an average daily weight gain of 104–145 g/d (Bai *et al.* 2010, 2011). Chakraborty *et al.* (1991) found that feeding dairy cattle with an ensiled mixture of WH, rice straw and molasses had shown an increase in milk yield. Bagnall *et al.* (1974) suggested to preserve the silage of water hyacinth for future use.

Feed for non-ruminants

For pig: The high cost of concentrated feed and non-availability of feed ingredients has also been identified as major constraints for pig producers in Sri Lanka (Wickramaratne 2002). Pig has a well-developed large intestine; hence a wide range of materials including some fibre can be digested (Gunaratne *et al.* 2009). Exploiting this advantage, the farmers use many low quality materials in pig feeding. Several studies had been conducted to find the potential of non-conventional feed materials in pig feeding including *Colocasia* yams (Ravindran 1987), kapok seed meal (Ganegoda and Siriwardena 1978), arrack distillery spent wash (Ganegoda 1983) and Eppawala rock phosphate (Ganegoda *et al.* 1986). However, inadequate studies have been done to evaluate WH as a feeding material for pig in Sri Lanka. Feeding boiled and chopped WH with rice bran, vegetables, copra cake and salt has been practiced for years as a feeding material for swine by Chinese pig farmers (Ndimele *et al.* 2011). Further he reported that WH can become a worthy feeding material for pigs, ducks and pond fish after cooking fresh WH with rice bran, fishmeal and mixing with copra meal. A study conducted by Men *et al.* (2006) revealed that pig had shown good acceptance for WH and the pigs fed on WH based diets had better carcass appearance than the common diet-fed pigs in Vietnam, because, pork exhibited low back-fat and body fat with excellent meat productivity (Choi 2004, Kim 2012). Inclusion of 5-15% of WH biomass in the pig feed did not affect daily gain in feed intake, fat thickness and loin eye area compared to control (Cui *et al.* 2004). Broiler diets

with 3–7% dry WH did not have negative effects on the average daily gain, feed efficiency and carcass performance (Xie *et al.* 1999).

Poultry feed: Poultry production is the rapidly growing sector in the globe as well as in Sri Lanka (Prabakaran 2003). Chicken are considered mostly consumed animal protein source among Sri Lankans (Silva *et al.* 2010). Most of the farmers rely on commercial poultry feed and self-mixed feed to feed chicken. Ducks and geese are the least types of poultry in Sri Lanka. Several studies have been conducted to utilize WH. Lu *et al.* (2008) reported that when ducks were fed 50 g fresh WH per day for a month, they showed better daily feed intake and higher egg-laying capacity in the treatment group compared to the control group. Further, he found that not only the feed intake was enhanced, but also the egg production performance, eggshell thickness, level of feed digestion and utilization were increased after feeding freshwater hyacinth. This emphasized that adding WH roughage in diet can reduce production costs without decreasing the productivity and economic return. However, Men and Yamasaki (2005) found that a replacement of 5 to 25% of a commercial diet by fresh WH to growing ducks decreased performance, but was economically profitable due to the lower feed cost.

Animal feed: Even WH is a good potential for animal feed based on the nutrient value, however this plant may contain toxic materials from the source of biomass. The heavy metals like cadmium (Cd), chromium (Cr), lead (Pb) and mercury (Hg), and metalloids such as arsenic (As) and fluorine (F) can be absorbed by WH because of having greater capacity in adsorbing, absorbing and accumulating heavy metals (Zhou *et al.* 2005, Shi and Zhao 2007). Roots have three times high capacity to hold and transport the toxic elements than the other parts and tissues of WH (Yan and Guo 2017). They suggested that WH growing in industrial waste water and in waters surrounding mining areas may be unsafe to utilize as feed.

It can be concluded that utilizing WH as a livestock feed is one of the better approaches out of many other ways of controlling the growth of this plant. Unlike Sri Lanka, countries like China, India, Vietnam have already identified the tremendous potential of WH using as a livestock feed after proper treatment and inclusion levels.

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