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A Review for Understanding the Reasons of Vanishing Sundari Tree *Heritiera fomes* Buchanan- Hamilton from Sundarban Mangroves

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ABSTRACT

The glory of Sundarban, the World Heritage Site (UNESCO 1987), is associated with the distribution of Sundari tree, *Heritiera fomes.* High complexity in habitat structure and environmental variability has enriched its floral and faunal biodiversity. This tree is only timber producing plant among 'true mangrove' species and popular as traditional folk medicine. The distribution of this native species is highly threatened by several factors. Though, the other mangrove species have showed the capability to adjust the changing environment for their existences in Sundarbans, why this particular species is on the verge of extinction. Research works on *Heritiera fomes* indicate several physiological disparities with changing hydrological parameter as major thrust for its survival in its own homeland.

Keywords Sundarban, *Heritiera fomes,* Threats, Anatomical structure, Hydrological parameter.

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INTRODUCTION

The Sundarbans world's largest contiguous mangrove forest with an approximate area of 10,200 sq km area is spanning the costal segments of Bangladesh (62%) and India (38%) (Ghosh *et al.* 2015, Dasgupta *et al.* 2016). Matrix of tidal flow and fresh water discharge has flourished into a unique spectrum of biological diversity there (Mitra *et al.* 2005). Worldwide most accepted opinion for the naming of Sundarbans is that it was derived from the name of Sundari tree, *Heritiera fomes* Buch-Ham. The distribution of this species is limited in the Sundarbans mangroves of India, Bangladesh, Myanmar, Thailand and Northern Malaysia (Kathiresan *et al.* 2010). According to IUCN red list Conservation Category, *H. fomes* which is a 'true mangrove species' and is designated as an endangered species from 2010 (Kathiresan *et al.* 2010).

A closely related species *Heritiera littoralis* Dry and ex Ait. is reported well distributed in mangrove forests of Andaman and Nicobar Islands (Singh 2012) and in Bhitarkanika mangroves (Pattanaik *et al*. 2008) but scattered distribution is reported only in deep forests of Indian Sundarbans (Naskar and Mandal 1999). This supports the idea that *H. fomes* might have migrated to land and evolved as a new species during the evolutionary process (Mukherjee *et al.* 2003). In the Sunderbans, it is the late seral species in newly formed inlands with sweet, brackish and saline water (Alim 1979).

MATERIALS AND METHODS

Vanishing trend

The rate of mangrove forest destruction was much faster than that of inland forest and coral reefs worldwide with maximum (35% loss) magnitude from 1980 to 2000 worldwide (Millenium Ecosystem Assessment 2005) which might have fastened with the rate of population declination of *Heritiera fomes* (GRB EMP 2012). The vegetation pattern arranged by Prain (1903) indicates the dominancy of this species in the central part of Sundarbans in early 20th century (Mandal *et al.* 1989). But the scenario has changed to stunted growth and scattered distribution in Indian part of Sundarbans during late 20th century (Chaudhuri and Chaudhury 1994). In Bangladesh part of Sundarbans where *Heritiera fomes* was evenly distributed, is also shifting eastwards (low saline zone) with almost entire retreatment from central and western part of Bangladesh (Dasgupta *et al.* 2016). Within a period of 38 years (1977-2015), distribution of *Heritiera fomes* and *Excoecaria agallocha* has decreased by 9.9% in Bangladesh part of Sundarbans (Ghosh *et al.* 2016). There is a prediction that in future *Heritiera fomes* along with some other mangrove species (adapted at low salinity) will be potentiality replaced by *Ceriops decandra* (Goran) from Sundarbans (Dasgupta *et al*. 2016). There is a prediction that within 2010 approximately 40% of *H. fomes* population will be vanished compared to data recorded in 1950 (FORESTAL 1960).

Increasing salinity as a major threat

Moribund status of many tributaries of River Ganga is creating a serious shortage of fresh water supply to Sundarban mangrove forest especially during post-monsoon time. In anticipation this is intensifying the problem of salinity intrusion and is gradually increasing the salinity level of water and soil substratum (Islam and Gnauck 2008, Banerjee 2013). Construction of Farakka Barrage has aggravated the adverse condition (Aziz and Paul 2015). *H. fomes* is considered as bio-indicator of climate change due to its strong preference extremely low saline condition in estuarine mangrove regions (Chaudhuri and Choudhury 1994, Mitra *et al.* 2004). *Heritiera fomes* is very sensitive to a change of 1.0‰ salinity (Ahmed *et al.* 2011). Annual growth rate of Sundari tree is reduced with increasing salinity (Aziz and Paul 2015). Above the optimal pH (> pH 6.5) phosphate absorption got reduced in *Heritiera fomes* and showed various pathological symptoms like top dying, invasion of bacterial and saprophytic diseases (Chaffey *et al*. 1985). In previous studies, the enhanced salinity was thought to be the main causal factor of top dying disease in *H. fomes* but recent hypothesis justified the interaction of other edaphic factors to induce top dying in Sundri (Awal 2014). 45.2 million Sundari trees have been affected by top dying disease in Bangladesh of which at least 20 million trees have been seriously affected (Chaffey *et al.* 1985). Photosynthesis of most mangrove species sharply declines when the air temperatures exceeds 35ºC (Moore *et al.* 1973). *Heritiera fomes* (Sundri) is the pre-dominant mangrove tree species due to its great support (65%) to the total merchantable timber from mangrove forest (Chaffey *et al.* 1985, Siddiqui 2001). Illegal cutting of trees has caused a significant change in spite of government banning on timber extraction (Akhter 2006).

RESULTS AND DISCUSSION

Anatomical and physiological inability

To combat the problem of salinization many mangrove plant species are well adapted with structural complexity such as salt exclusion mechanism at root level, foliar salt secretion adaptability and reduction capacity of osmotic potential (Drennan and Pammenter 1982, Sivasankaramurthy 2012). Morpho-anatomy play important role in adaptation in mangroves Rodriguez *et al.* (2012). Rooting pattern of *H. fomes* may be another reason for exposed salinity stress as their roots spread on the soil surface rather than deep penetration (Kathiresan *et al.* 2010). Maximum part of the root surface cannot absorb water and nutrients because of substrate salinity (Medina 1999). The function of salt accumulating system normally induces photosynthesis for pumping ions into the specialized tissues along with the benefit of structural development (Medina 1999). Large aerenchymal lacunae in the root cortex which are efficient for conservation of internal oxygen are found in most of the mangrove species except *Heritiera fomes* (Pi *et al.* 2009).

At higher salinity level, the *H. fomes* trees might be perhaps forced to face the stress by the functional changes of antioxidant enzymes, modification of leaf and chloroplast structure, alteration in rate of transpiration, photosynthesis and stomatal conductance (GRB EMP 2012). An increased accumulation of salts was observed in the plants body with increasing salinity level (Karim and Karim 1999). Elevated assimilation rate coupled with increased chlorophyll content, more mesophyll and stomatal conductance and higher specific leaf area are quite common in *H. fomes* at minimal soil salinity (Rodriguez *et al*. 2012, Ball and Farquhar 1984, Burchett *et al*. 1984). In Indian Sundarbans the available irradiance (µmol m-2 s-1 PHOTONS PAR) is very high than the maximum requirement for photosynthesis in *H. fomes* (Nandy and Ghose 2001). Avoidance at high light intensities is controlled by the correlation of photosynthesis and stomatal size and frequency which was recorded with lowest value in *H. fomes* (Nandy *et al.* 2005). Rate of transpiration in *H. fomes* is reduced due to deeply sunken stomata which are covered by peculiar type of trichomes (Mandal and Ghosh 1989, Rodriguez *et al.* 2012). The low palisade-spongy ratio in leaves of this species is due to poor development of palisade cells traversed by large intercellular spaces (Rodriguez *et al.* 2012, Das *et al.* 1995). It was also documented that in *H. fomes* the salt glands are absent and leaf pubescences were not found developing inability for the survival of the species in stressed environment (Reef and Lovelock 2015). At higher salinity the seedlings are forced to face increased sodium concentration with reducing potassium and carbon concentration (Hossain *et al.* 2014).

Difficulty in germination

There are some gaps in research works of about 50 years (from 1903-1960) when we see there is no concretized data available regarding the distribution and status of *Heritiera fomes* in Sundarban mangroves. Due to this consequence it is also not clearly known when this mangrove species started the vanishing event especially from Indian part of Sundarbans. Being a representative with a long life span (40 years) (Kathiresan *et al.* 2010) it is a K-selected species with low resilience property. Even in absence of anthropogenic pressure the k- selected species usually takes long time to set back to previous state after any catastrophic disaster. Thus vivipary which is a modified pattern of epigeal germination are lacking in *Heritiera fomes* but has evolved in many other mangrove species (Das and Ghose 2003). Since the seeds of *H. fomes* are matured at the onset of pre-monsoon season (usually in March) (Upadhyay and Mishra 2010) then the salinity of surface soil is comparatively higher due to evaporation and those may possibly make trouble for germination or propagation of saplings. The seeds of *H. fomes* showed lower germination and less viability at higher salinity levels compared to other species (Hossain *et al.* 2014). The situation might be unfavorable with occasional cyclonic storm surge resulting in salt water intrusion far upland of high tide line.

CONCLUSION

Finally it can be suggested that the environmental stresses along with anatomical inequity in together are pushing *Heritiera fomes* to be physiologically inefficient for surviving in habitat with increasing salinity. The time that is not so far away when there will be necessity of using magnifying glasses to find out the Sundari tree, *Heritiera fomes* from Indian part of Sundarban mangroves.

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