FACTORS RESTRAINING THE NATURAL REGENERATION OF REED BAMBOO *OCHLANDRA TRAVANCORICA* AND *O. WIGHTII* IN WESTERN GHATS, INDIA

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GOPAKUMAR B & MOTWANI B. 2013. Factors restraining the natural regeneration of reed bamboo *Ochlandra travancorica* and *O. wightii* in Western Ghats, India. The natural regeneration of *Ochlandra travancorica* and *O. wightii* is restrained by many factors. These factors include invasive growth of *Mikania* weed, fruit predation by boars, rodents, larvae of *Achroia grisella*, seedling predation by elephants and other herbivores, human activities such as clear felling, spreading fires, cleaning the bamboo grounds after flowering, construction of river embankments, establishing plantations and forest encroachments. The attack of *M. micrantha* and *Sus scrofa* gave the most deleterious impacts besides human disturbances on natural regeneration of reed bamboo. The fruiting of endemic *O. wightii* supported the population of an endemic rodent *Platacanthomys lasyrus*.

Keywords: *Achroia grisella*, *Mikania micrantha*, habitat destruction, seed predation, spiny tree mouse, *Sus scrofa*

GOPAKUMAR B & MOTWANI B. 2013. Faktor penghalang pemulihan semula jadi buluh *Ochlandra travancorica* dan *O. wightii* di Ghats Barat, India. Pemulihan semula jadi *Ochlandra travancorica* dan *O. wightii* dihadkan oleh banyak faktor. Antaranya ialah pertumbuhan rumpai *Mikania*, buahnya dimakan oleh babi hutan, serangan tikus, serangan larva *Achoria grisella*, anak benihnya dimakan oleh gajah dan herbivor lain serta aktiviti manusia seperti tebangan habis, pembakaran hutan, pembersihan kawasan selepas buluh berbunga, pembinaan benteng sungai, penubuhan ladang dan pencerobohan hutan. Serangan oleh *M. micrantha* dan *Sus scrofa* serta gangguan manusia membawa kesan paling buruk pada pemulihan semula jadi buluh. Penghasilan buah oleh *O. wightii* yang endemik menampung populasi tikus *Platacanthomys lasyrus* yang endemik.

INTRODUCTION

Bamboo is a woody grass belonging to the subfamily Bambusoideae of the family Poaceae. Members of the genus *Ochlandra*, referred to as reed bamboo, are thin-walled and thickly-clumped endemic bamboo of the southern Western Ghats of India (10 species) and Sri Lanka (1 species). They are the preferred raw material for traditional cottage industries and modern paper industries. In the traditional sector, they support the livelihood of over 300,000 workers belonging to the socially and economically weaker sections of the society (Seethalakshmi & Gnanaharan 1998). The annual requirement of bamboo in Kerala state is 314,000 tonnes, which is much less than its availability (Surendranath 2004). *Ochlandra travancorica* and *O. wightii* are important members of the group thriving only in the wet hill slopes and stream sides of Western Ghats. The existence of these two endemics is dependent on the sustenance of their native habitats. Habitat destruction, anthropogenic activities, invasion of alien weeds and animal predation of seeds and seedlings reduce their regeneration.

Both *O. travancorica* and *O. wightii* are monocarpic or semelparous, regenerate naturally through seeding at intervals of 30 or more years, determined by genetic clock and environment (Janzen 1976). The flowering process is usually triggered by hot weather, but seeding coincides with rains. Flowers are unifloretted pseudospikelets, which are

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dichogamous and protogynous. Each floret is tubular and oval, 3 to 5 cm long and 1 to 2 cm broad at the stigma-exposed stage. Geitonogamous or allogamous pollination by the anemophilous pollen can result in mature fruits at an average of one month. Having no dormancy period, ripened fruits germinate soon after fall after being soaked in rain water. Fruiting is associated with defoliation and gradual death of parent clumps. Dead culms remain upright from 6 months to more than 1 year, slowly decaying before toppling down. During the period, seedlings within the clump and periphery establish successfully. Usually a healthy clump of *O. travancorica* or *O. wightii* produces an average of above 500 seeds, of which ≥ 90% germinate resulting in seedling carpets in the absence of predation and external disturbances. Disturbed clumps show only 3 to 17% recruitment at the end of 2 years. The present paper attempts to trace factors detrimental to the regeneration of these species.

MATERIALS AND METHODS

Since 2008, *O. travancorica* has been flowering among the segmented semi-evergreen forest at Palode, on the banks of Vamanapuram River (8° 43' N, 77° 1' E) and adjacent hillocks, which are part of the Palode Forest Range, Thiruvananthapuram Division. *Ochlandra wightii* has been in bloom since 2009 in the evergreen and semi-evergreen forests of Rose Mala and Rajathottam (8° 56' N, 77° 10' E), which are part of the Aryankavu forest range, Thenmala Division. Data on flowering ecology were recorded from these sites (Figure 1) and compared with those from Kottoor, Sankhili and Moozhiyar. The vegetative features were studied from clumps at Bonaccaud and Braemore. Phenological changes were monitored and recorded through frequent field visits. At Chonanpara (8° 3' N, 77° 9' E), Kottoor, one population of *O. travancorica* (3 km^2) had fruited. It is now in the process of regeneration (1-year-old seedlings). At Sankhili (8° 45' N, 77° 10' E), *O. travancorica* was represented by 4–7-year-old seedlings, resulted from the 2005–2008 fruiting. At Moozhiyar (Pathanamthitta District) (9° 19' N, 77° 4' E), a major part of the bamboo forest has now turned into seedlings of 4–6 years, following flowering in 2006–2008. Flowering of O. *travancorica* was noticed to have begun at Koruthode (9° 28' N, 76° 58' E), Kottayam District. At Achenkovil (Kollam District), the *O. travancorica* population is 13–15 years old. At Idamalayar (10° 15' N, 76° 50' E) and Pooyamkutty (10° 08' N, 76° 47' E) (Ernakulam District), there is vast *O. travancorica* vegetation comprising mature vegetative clumps. Voucher specimens of the studied species were deposited at the Tropical Botanic Garden, India. In addition to the primary data collected from study areas, interviews helped to gather more information about predators. For photography, a camera was used while for locating populations, a GPS (global positioning system).

RESULTS AND DISCUSSION

Factors hampering the regeneration of *Ochlandra* population are as below.

Weed (*Mikania*) invasion

The mile-a-minute weed, *Mikania micrantha* had seriously hampered the regeneration of

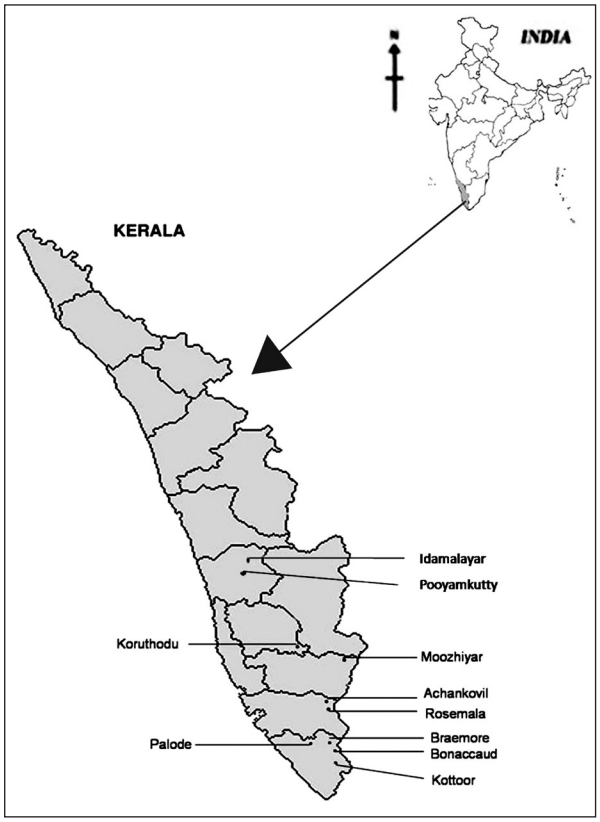

Figure 1 Study areas

reed bamboo. Their mass multiplication and rampant growth enabled them to suppress native flora, including endemics such as *Ochlandra* spp. Even if healthy *Ochlandra* plants could resist weed overgrowth during the vegetative phase, defoliation during the reproductive phase made them susceptible to weed invasion, especially in open wet habitats. Leafless or dead culms acted as props and canopy openings allowed luxuriant light incidence, thus facilitating weed overgrowth. At Palode, on the banks of Vamanapuram River and its tributaries, *O. travancorica* had gregariously fruited during the 2008–2010 and part of the 2007–2012 flowering phases. *Mikania* weed had overgrown 125 of the 350 fruited clumps in 2009, increased to 150 of 400 in 2010 and 175 of 400 in 2011. Among the attacked, seedlings of 150 clumps (37.5%) were completely lost by the third year; 25 clumps which remained were left with ≤ 5 seedlings only. The microclimatic change associated with parent defoliation, death and profuse light irradiance resulted in the emergence of 50–500 seedlings per clump, which was being disrupted by *Mikania* invasion. The weed denied sunlight and soil nutrients to the developing *Ochlandra* seedlings. At the study area (Palode), *Mikania* invasion had resulted in complete destruction of seedlings of (150 of 400 clumps) (Figure 2). The invasion was spreading to newer areas. At Moozhiyar, regeneration of 10% of the flowering *O. travancorica* population was prevented by *Mikania*. At Koruthode, the flowering population was attacked by *Mikania*.

Figure 2 *Mikania micrantha* over a flowered and dried clump

Other weeds found inhibiting natural seedling regeneration of fruited clumps of *Ochlandra* included *Puereria phaseoloides, Merremia umbellata* and *M. vitifolia*. In *O. travancorica* flowering populations, each of these climbers caused regeneration failure in 1 to 2% clumps.

Seed, spikelet and seedling predation

Ochlandra seeds are short-lived baccate caryopses. They serve as food to many forest animals at the time of seeding. A period of approximately 1 month is needed for a female stage floret to develop into a mature fruit and fall. These fruits and spikelets were found to be devoured by the following animals.

Boars

In the riparian, disturbed forest at Palode, where there was higher wild boar (*Sus scrofa*) population, majority (90 to 100%) of *O. travancorica* fruits shed around parent clumps were eaten by them. Their feeding is nocturnal and the entire fruit will be devoured, with no remains left. Predation was less damaging in initial years (2008–2009) but became near exhaustive towards later years (2010–2012).

The wet soil was thoroughly ploughed (rooted) and harboured numerous footprints of boars. The hoof marks and droppings were identified as those of boars based on Jayson and Easa (2004). Direct sightings also confirmed the identity. Heavy fruit predation by boars was recorded on *O. wightii* population at Rose Mala and *O. travancorica* populations at Kottoor, Sankhili, Moozhiyar and Koruthode. The soil-rooting by boars also destroyed part of the seedling population. During the vegetative stages, new culms and rhizomes were also eaten by boars.

Rodents

Fruits and spikelets were eaten by rodents (rats, mice and porcupines, members of Muridae). Their eaten remains were found scattered under clumps. Their bites were of scrapping type. Rats and mice are nocturnal feeders, causing 5 to 10% fruit damage. Masting of bamboo caused rat population

to increase in multitudes, heavily damaging cereal crops. During fruiting of *O. travancorica* in the fragmented forest at Palode, an increase in the number of mice and rats occurred with fruiting. Sherman's traps were placed among fruiting clumps of *O. travancorica*, which resulted in the capture of the common rat *Rattus rattus*. Similar observations were recorded in Rose Mala and Rajathottam forests, whereby a hike in the number of rats (*Rattus* spp.), common mice (*Mus* spp.) and spiny tree mice (*Platacanthomys lasiurus*) occurred. Traps were placed among culms of fruiting *Ochlandra* plants, which led to the capture of *R. rattus* and *P. lasiurus*. Observation in captivity proved similarity of bites on fruits.

The porcupine *Hystrix indica* also predates young *Ochlandra* seedlings (presence of spines and footprints). Rats also reduced the number of young seedlings, eating their tender growing portions and discarding the rest. As a result of rodent predation, the seriously damaged seedlings died out, while the partially damaged seedlings exhibited stunted growth and were eliminated in due course.

Elephants

Heavy predation of seedlings by elephants (*Elephas maximus*) was recorded from the protected forests of Rose Mala (on *O. wightii*), Kottoor and Moozhiyar (on *O. travancorica*). Mature clumps were eaten by elephants at Bonaccaud, Idamalayar and Pooyamkutty. In addition to direct sightings, elephant predation was evident from the presence of dung containing *Ochlandra* plant parts, footprints and loss of seedlings. However, wild elephants were not sighted visiting the fragmented riparian forests at Palode since the forest continuity was disrupted by human inhabitations. Forest dwellers, including Kani, Muthuvan and Kurichya tribes of the state, have narrated witnessing seedling predation of *Ochlandra* spp. by elephants. Elephants often pluck seedlings from the ground, eat the aerial portions and discard the rest. Such predation causes heavy seedling loss. Young shoots of mature reed bamboo were also eaten by elephants, besides leafy twigs. This prevents clump expansion and leads to resource depletion.

Insect larvae

The larvae of the fly *Achroia grisella* was found inhabiting the spikelet/fruit clusters of *O. wightii*. Dead spikelets and fruits remained adhered together failing to fall. Such nodal clusters were inhabited by one or more larvae which feed on the spikelets and fruits. Affected spikelet clusters, on detailed examination, were found to carry most stages of larvae, from new hatchlings to pupae.

By keeping infected spikelets and fruits under observation in covered but aerated bottles, larvae and adults were collected (Figures 3 and 4). It took 4 to 12 days for the adults to emerge. They were identified as *A. grisella* (Lepidoptera: Galleriidae). Among the *O. wightii* population at Rose Mala, 10–15% of the fruits were damaged by the larvae. Among the *O. travancorica* population at Kottoor,

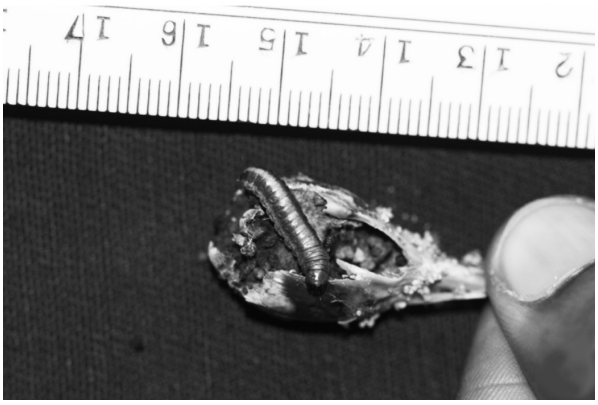

Figure 3 *Achroia grisella* larva

Figure 4 *Achroia grisella* adult

5–10% of fruits were damaged by *A. grisella* larvae in March 2011. Thus, the larvae posed a serious threat to the regeneration of the bamboo.

Anthropogenic disturbances

Clear felling /clearing of reed bamboo areas

Complete cutting down of *Ochlandra* clumps resulted in its poor regeneration. Number and length of new shoots diminished by one third or even less on the year succeeding clear cutting. This reduced clump health, flower and fruit production. Annually felled clumps, close to villages, were found possessing only short (2–3 m), thin (0.5–1 cm) and unhealthy shoots. Clear felling resulted in resource depletion in various parts of the state such as Kulathupuzha, Idinjar and in some coups of Ranni forest division. At Kottoor, the Chonanpara and Mankode tribal settlements and forest roads were set up after removing *Ochlandra* vegetation. This resulted in fragmentation of the reed forest.

Local government authorities have undertaken clearing of riverbank vegetation as part of developmental and employment guarantee schemes. In this process, many rare plants were destroyed. Removal of debris of flowered *Ochlandra* clumps was also done during this exercise. This resulted in seedling removal and seedlings that were left behind could not survive because of habitat destruction, i.e. exposure to extreme weather (hot sun, flood) and grazing by cattle. Seedling loss during clearing of the flowered population at Palode for forest nursery and damage to the riparian reed vegetation on the Trivandrum–Schenkottah roadside were observed. Table 1 shows a steady decline in the reed collection from 2005–2006 till 2010–2011. This is attributed to the inadequate regeneration following flowering and felling.

Forest fires

Even when the aboveground portions of reed bamboo were charred by fires during the vegetative phase, they regenerated from the underground rhizome system, as evidenced in a population of *O. travancorica* at Palode in 2000. However, the same proved destructive during the flowering phase, whereby young seedlings were destroyed along with parent plants as observed at Kottoor in 2011.

River embankments

The close contact between aquatic and terrestrial ecosystems creates rich and diverse riparian vegetation. Man-made rocky embankments prevent this close association, denying foothold for precious plant and animal lives. In the process of construction of such structures, which are usually associated with road widening and side strengthening, the narrow green belt between water ways and roads are cut down (Figure 5) and filled over with dugout soil from elsewhere, resulting in habitat destruction. This leads to destruction of many endangered riparian species. Examples

Figure 5 Loss of clumps during embankments

Table 1 Reed collection from the forests of Ranni Division

O. travancorica	2005–2006	2006–2007	2007–2008	2008–2009	2009–2010	2010–2011
Collection (metric tonnes)	11,559	6962	7568	7503	2291	2712

Source: Anonymous (2010)

are reed bamboo population destruction on the banks of Vamanapuram, Chittar and Karamana Rivers (Kerala).

River–valley projects

The hydroelectric/irrigation dams constructed at Thenmala, Idamalayar, Peppara, Neyyar, Kochu-Pampa, Kakki, Moozhiyar and Idukki of Kerala State came into being after drenching vast extent of riparian forests, rich in reed growth. At Moozhiyar, dams, power station and associated building complexes were built damaging vast reed forests. New river–valley projects such as Pooyamkutty, Athirappally and Vamanapuram are posing fresh threats to the reed bamboo vegetation. If the Athirappally hydroelectric project materialises, a stretch of 28.4 ha of low-elevation riparian forest will be submerged (Nila Foundation 2010). The Periyar basin in the high ranges of Kerala has a series of 12 large dams which directly or indirectly result in destruction of about 4000 km^2 of rainforests and grasslands.

Expansion of man-made forests/plantations

The Forest Development Corporation and Plantation Corporation are government agencies in Kerala engaged in spreading and upgrading forest plantations. Plants widely grown in these plantations are *Acacia auriculiformis, A. mangium, Eucalyptus* sp., *Artocarpus hirsutus* and *Anacardium occidentale*. Any one species is repeatedly grown at each place. Monocropping, especially of *Acacia,* prevents growth of native flora, does not support native fauna and results in decline of soil fertility and ground water levels. Every year such forest plantations are expanded at the risk of native plants such as *Ochlandra* spp. The *A. hirsutus* plantation at Palode on the banks of Vamanapuram River, which was established in 1955, removed a large part of *O. travancorica*. At Kottoor, many reed areas were clear felled and rubber (*Hevea brasiliensis*) plantations were raised.

The growth of *Mikania* was more damaging to the *O. travancorica* population at Palode, which formed part of a moist deciduous forest than to *O. wightii* at Rose Mala, which formed part of an evergreen forest. Similar observation on the intolerance of the weed to deep shade was made by Sankaran et al. (2001).

Weed infestation was reported as a reason for bamboo seedling death along with burning and clear felling (Banik 1988). Basha (1991) also reported that *Mikania* weed invaded flowered reed areas affected by forest fires at Pooyamkutty. Noushad (2008) also reported *M. micrantha* infestation as a threat to the *Ochlandra* plants. *Merremia umbellata,* in spite of being a weed, does good to the fruiting of leafless *Ochlandra* culms by acting as a sort of shade.

The study on the reed forests at Bonaccaud, Sankhili, Idamalyar and Moozhiyar found elephants feeding extensively on young shoots and leaves of *O. wightii* and *O. travancorica*, causing poor clump expansion and yield, thus resource depletion. Their predation of *Ochlandra* seedlings were recorded from forests of Rose Mala and Moozhiyar. The use of *Ochlandra* plants as food by elephant herds was reported previously at the Peppara Wild Life Sanctuary by Jayson and Christopher (2008). Koshy et al. (2010) attributed satiation of large predators such as elephants as one of the reasons for larger leaf sizes in *Ochlandra* plants.

On the degrading riparian forest at Palode where *O. travancorica* was at its end of mass flowering, most fruits fallen were eaten by wild boars. Boar sightings and crop damages had increased in par, indicating an increase of boar population. Ickes (2001) observed a big increase in the number of *S. scrofa* and subsequent deleterious impacts on the understorey plant community in a Malaysian lowland rainforest. He attributed such increase in boar population to the conversion of large forest areas to small fragments bordered by anthropogenic landscapes, absence of feline predators and presence of year round food supply from surrounding agricultural areas. This is true in the case of narrow riparian reed forests of Vamanapuram river banks. The increase in population of *S. scrofa* caused the reed–bamboo population to deplete through heavy fruit predation and seedling removal. Ickes et al. (2001) opined that the heavy fruit predation by boars might account

for the mast fruiting phenomenon of plants in South-East Asia. Boar-rooting could alter the vegetation and lead to weed invasion as well.

It is widely accepted that there exists a relation between explosion in rodent population and bamboo flowering. Rodent outbreaks occurring in north-east India corresponded with the gregarious fruiting of the bamboo *Melocanna baccifera*. To a lower extent, hyper-increases of certain rodents were noted in *Ochlandra* fruited areas. It was reported that rodents which increased in par with bamboo fruiting belonged to the *Mus* and *Rattus* genera (John & Nadgauda 2002). However, in this study fruiting of *O. wightii* had given a boost to the population of an endemic rodent, *P. lasiurus* or Malabar spiny tree mouse. Rodents predating young bamboo culms, rhizomes and seeds were described by Mc Neely (1995). His list includes wild cattle and deer, primates, pigs, rats, mice, porcupines and squirrels as predators of bamboo plants.

The infestation of *A. grisella* larvae on fruits of *O. wightii* and *O. travancorica* is a new record. The larva acting as a pest on reed bamboo fruits was first reported by Mathew and Seethalakshmi (1998) in *O. ebracteata*. The larvae accounted for 10–15% fruit damage in *O. wightii* and 5–10%, in *O. travancorica*. The first report in 1998 was also from a similar mountainous reed forest, Achenkoil, part of the Western Ghat hill ranges. In 2012, all *Ochlandra* clumps at Achenkoil were in the vegetative phase. At Palode, no *Achroia* attack was observed in *O. travancorica* fruits but attack was prevalent at Kottoor.

Depletion of reed resource is caused by the collection of culms from reed forests during the closure period, i.e. sprouting season (Noushad 2002). Using forest land for commercial plantations, agricultural cultivations and human settlements led to the destruction of reed resources. Shifting cultivation, once a common practice in forests of Kerala, did both harm and good (Basha 1991). Even though forest fires failed to destroy reed growth during the vegetative phase, the same proved destructive during the reproductive phase.

Decline in the extent of natural forests due to agricultural extension, river–valley projects and expansion of man-made forests was reported as a major factor causing depletion of reed (*Ochlandra* spp.) population in the state of Kerala (Kumar 1988). Hazards in the conversion of natural forests comprising reeds and bamboo into plantations of *Eucalyptus* and *Acacia* were detailed by Surendranath (2004). Such a conversion turned nearly 3000 ha of fertile forest land in Muthanga Range, Wayanad District, Kerala completely barren. Such forest conversions into plantations increased human–wildlife conflicts. Gururaja et al. (2008) attribute landuse changes aimed at meeting the needs of human population as a paramount factor in the decline of biodiversity all over the world. Large-scale clear felling of reed forests by paper mills was stated as a reason for their destruction (Ajithkumar 1985).

The recorded regeneration of *O. travancorica* and *O. wightii* in some forests (Table 2) showed gradual reduction in the number of individuals recruited as the years passed. Similar observations were made by Seethalakshmi et al. (2009) from Nannattupara, Kerala. The importance of riparian forests, where most

Table 2 Regeneration recorded (December 2011)

Parameter		*Ochlandra travancorica*			*Ochlandra wightii*		
		Palode	Kottoor	Moozhiyar	Rose Mala	Braemore	Bonaccaud
Age of seedling population (years)		3	2	5	1	13	9
No. of clumps/ 10 m × 10 m quadrat	Range	20–170	60–180	10–70	65–80	38–60	35–70
	Average	70	98	40	78	53	55

Ochlandra plants belong, was reiterated by Amitha (2003). The riparian forest is a unique and rich natural ecosystem which has great influence on the adjacent aquatic as well as terrestrial systems. Reed bamboo stabilises and safeguards the riverbanks from erosion. Therefore, removal of riverbank bamboo vegetation is totally harmful to the ecosystem.

CONCLUSIONS

Ochlandra travancorica and *O. wightii* are endemics of the southern Western Ghats. They are adapted to moist hill slopes and banks of watercourses. They are integral to the ecological stability of the region. Reed bamboo prevents top soil from eroding, acts as reinforcements to banks of swift flowing and annual flooding waterways. These bamboo species have to overcome many constraints in survival. They protect many forest fauna by providing shelter and food. These species are important economically since they support the livelihood of thousands of poor, act as raw material for traditional handicraft industries and modern paper industries. Their existence is under threat. They deserve special attention of conservationists and policy-makers.

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