Journal of Aquatic Biology and Fisheries Vol. 2/2014/ pp. 458 to 466

SEASONAL POOLS ON LATERITIC PLATEAUS: UNIQUE HABITATS OF GREAT DIVERSITY – A CASE STUDY FROM NORTHERN KERALA

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Received on: 10 October 2013, accepted on: 12 December 2013

Abstract: Northern Kerala, which is the type locality of laterite, is characterized by wide and flat to gently sloping plateau like tops where the soil cover is usually thin. These plateaus provide extremely diverse physical environments and thereby microhabitats leading to the development of specialized life forms. Present study was carried out at Madayippara lateritic plateau in Kannur District of Kerala State, South India, to assess and document the diversity and periodicity of herbaceous angiosperms and rare and endemic species confining to the seasonal pools of this lateritic plateau. The seasonal pools that are varying in their area, depth and soil cover, become water logged with the onset of southwest monsoon and dry up after the retreat of northeast monsoon. A series of species we noticed were progressively from the first shower of rains in May or June, until they become dry in the months of October-November. About 37 percent of the herbaceous species identified from the seasonal pools are endemic. Four new species were discovered from the seasonal pools of this plateau in the recent past. In addition to this, five other new taxa were also discovered from the same plateau by different workers. The area also harbors a number of rare species in the seasonal pools. The rich diversity shown by the pools can be attributed to the geological setting of the area together with the climatic characteristics acting on them. The study reveals that Madayippara, like other lateritic plateaus of Northern Kerala, are rich in plant diversity due to its micro-ecosystems and are under threat. *In situ* conservation of the entire habitat is the only solution as *ex situ* conservation measures cannot provide intricate microclimatic requirements artificially.

Key words: Aquatic ecosystems, Northern Kerala, Endemism, Seasonal pools, Lateritic plateaus.

INTRODUCTION

Laterite was first named and described by Buchanan in 1807 and is of varied appearance (Roy Chowdhury *et al.*, 1965). Minerologically, laterite is a mixture of varying proportions of goethite, hematite, gibbsite, boehmite and kaolin and rutile, to a lesser extent. Laterite is a product of intense chemical weathering under leaching environment and subsequent or simultaneous induration. It is reddish in colour and is mainly composed of oxides of iron and aluminium. In Earth Science literature, Kerala is known as the type locality of laterite (Chandran *et al.*, 2005). In India, they are located along coasts and hill ranges of Peninsular region. They are highly porous in nature and often occur as capping over bauxite deposits. In many areas, it is present as a specialized form – the duricrust or ferricrete (if rich in iron) - which is a hard, almost impermeable outcrop. It is characterized by wide and flat to gently sloping plateau-like tops and is marked by conspicuous vertical scarp faces around the peripheries. Soil cover is very thin on the laterite plateaus. Owing to the absence of large trees on such plateaus they appear almost barren during winter and summer.

Lateritic plateaus provide extremely harsh physical environment for life forms. These conditions play a decisive role in the development of strongly seasonal vegetation, where more than 95% of the plant species complete their life cycle during monsoon period. Extreme environments of the plateau have led to the development of specialized plant communities, with large number of endemic and habitat specific species.

Madayippara Lateritic plateau located in the Madayi village near Payangadi town in Kannur District of Kerala State, South India, where the present study was carried out, lies between 12°01' - 12°03' N latitudes and 75°14' - 75°16'E longitudes. It forms a complex of peculiar microhabitats due

to difference in geographic terrain and soil cover for diverse forms of plants, mainly herbs. The area has an ancient history and is a centre of pilgrimage owing to the presence of a number of famous temples and mosques. The plateau is having altitudes 30 to 70 m from mean sea level. The top of the hillock is a laterite plain of about 365 ha (Balakrishnan *et al*., 2011). The area is having distinct wet and dry phases (Fig. 1a & b).

Madayippara is a flat toped plateau with scrub vegetation on the slopes. The upper part is having an undulating terrain without tree cover and appears barren in summer months. Different micro habitats like exposed rock surfaces, rock crevices, soil covered areas, perennial ponds and seasonal pools are noticed on the terrain, supporting large number of endemic and preferential species. During rainy seasons, small and shallow temporary pools are formed which support a large number of hydrophytes including endemic species showing various degrees of rarity. The present study was carried out to assess and document the diversity and periodicity of herbaceous angiosperms, rare and endemic species confining to the seasonal pools of this lateritic plateau. Attempts were also carried out to estimate the correlation of microclimatic data of the pools with the diversity. A comparison of the microclimatic data of soil covered plots on the plateau with that of the seasonal pools is also envisaged. Floristic and ecological studies on such plateaus are very meager except for some isolated efforts by different authors (Lekhak and Yadav, 2012; Rao *et al*., 2012; Watve and Thakur, 2006).

MATERIALS AND METHODS

Field visits were carried out covering all seasons for five years starting from January 2008. Plant specimens growing in seasonal pools were collected, identified by standard methods and documented by herbaria and photographs. The herbarium specimens were deposited in the Calicut University Herbarium (CALI).

For the representation of the microclimatic data of different seasons, sampling was done for a complete year on a monthly basis. Soil samples and weather data were collected from the quadrats towards the middle of every month in a year. Thirteen seasonal pools were selected at random on the plateau. Soil samples were collected regularly and analyzed for pH, water holding capacity and moisture content. Atmospheric temperature, soil temperature, water temperature and water pH of the pools were also recorded monthly. The results obtained were averaged for different seasons (pre-monsoon, monsoon and post-monsoon) and compared with the microclimatic data of sixteen soil covered plots that are selected at random on the same plateau.

Atmospheric, soil and water temperatures were recorded in the field using ordinary mercury bulb thermometer during peak hours (1 – 3 p.m.). pH of water in the seasonal pools were recorded in the field with Eutech ecoTester pH2 model pH meter.

For the estimation of soil pH, prepared 1:5 soil solution and then the pH of the supernatant was measured using Systronics Digital pH meter model MKV2.

For the estimation of water holding capacity, 50 g soil was put in a wet whatman's filter paper cone fitted on funnel placed on a conical flask. Water was poured to the soil uniformly drop by drop till few drops of the water spill out to the conical flask. The quantity of water poured to the soil and excess water collected in the flask were noted and thus water retained by the soil was calculated. The water holding capacity was calculated in percentage by dividing the water retained by the soil with the weight of the soil and then multiplying with 100.

For the estimation of moisture content, a known weight of the soil was kept at 70°C temperature in a hot air oven for 48 hours and reweighed. By deducting the final weight from the initial weight, the moisture content is calculated. The percent moisture content of the soil is calculated by dividing moisture content by initial weight and then multiplying with 100.

RESULTS AND DISCUSSION

Three seasons, *viz*. pre-monsoon (March – May), Monsoon (June – November) and post-monsoon (December – February) can generally be recognized on the plateau. The seasonal pools in the plateau are varying in their area, depth, soil cover and soil texture (Fig. 1c – f). The pools are just depressions on the plateau, either on

Fig. 1. a & b. views of Madayippara lateritic plateau; **a.** in monsoon and **b.** in summer; **c - f.** different types of seasonal pools on the plateau; **g & h.** a seasonal pool in summer and monsoon respectively.

Table 1. List of some of the endemic species identified from the seasonal pools of Madayippara Lateritic Plateau

Sl. No.	Species	Family	Status of Endemism
1	*Coelachne madayensis* Pramod & Pradeep	Poaceae	South India (Kerala)
2	*Eriocaulon cuspidatum* Dalzell.	Eriocaulaceae	Western Ghats
3	*Eriocaulon reductum* Ruhland	Eriocaulaceae	Western Ghats
4	*Geissaspis tenella* Benth. var. *tenella* Hook. f.	Fabaceae	Western Ghats
5	*Glyphochloa acuminata* (Hack.) W.D. Clayton	Poaceae	Peninsular India
6	*Heliotropium marifolium* Retz.	Boraginaceae	Peninsular India and Sri Lanka
7	*Isachne veldkampii* K.G.Bhat & Nagendran	Poaceae	South India
8	*Ischaemum rangacgarianum* C.E.C. Fisch	Poaceae	South India and Sri Lanka
9	*Lindernia manilaliana* Sivar.	Linderniaceae	Southern Western Ghats (Kerala)
10	*Murdannia ochracea* (Dalzell) G. Brukn	Commelinaceae	Peninsular India
11	*Murdannia semiteres* (Dalz.) Sant.	Commelinaceae	Peninsular India
12	*Neanotis subtilis* (Miq) Govacrts ex Punekar & Lakshmin	Rubiaceae	India
13	*Nymphoides krishnakesara* Joseph & Sivar.	Menyanthaceae	Southern Western Ghats (Kerala)
14	*Pogostemon deccanensis* (Panigrahi) Press	Lamiaceae	South India
15	*Rhamphicarpa longiflora* (Arn.) Benth.	Scrophulariaceae	India
16	*Rotala macrandra* Koehne	Lythraceae	Western Ghats
17	*Rotala malabarica* Pradeep, Joseph & Sivar.	Lythraceae	South India (Kerala)
18	*Rotala malampuzhensis* R.V. Nair *ex* C.D.K. Cook	Lythraceae	Southern Western Ghats
19	*Utricularia cecilii* Taylor	Lentibulariaceae	Western Ghats
20	*Utricularia lazulina* Taylor	Lentibulariaceae	Western Ghats
21	*Utricularia malabarica* M.K. Janarth. & Henry	Lentibulariaceae	South India (Kerala)
22	*Wiesneria triandra* (Dalzell.) Micheli	Alismataceae	Peninsular India

laterite rock or on soiled areas. If it is on rocks, thin layers of soil rich in organic matter has been noted, which support the vegetation. The pools get dried up in pre-monsoon and post-monsoon periods. They become water logged with the onset of southwest monsoon and dry up after the retreat of northeast monsoon (Fig. 1 g & h). Germination of ephemeral vegetation is noticed after the first shower in May end or early June every year. A series of species are noticed progressively until they become dry in the months of October-November. Almost all species are herbaceous and most of them complete their life cycle in a short period, as the pools dry up. About 37 percent of the species identified from the seasonal pools of Madayippara plateau are

endemic to different geographic areas and many are under different threat categories (Table 1). The notable and dominant species in the seasonal pool are *Geissaspis* spp., *Isachne veldkampii, Murdannia* spp., *Neanotis subtilis, Rotala* spp., *Eriocaulon* spp., *Utricularia* spp., *Blyxa* spp., *Drosera indica, Lindernia* spp., *Nymphoides krishnakesara, Oryza rufipogon, Rhamphicarpa longiflora, Fimbristylis* spp., *Wiesneria triandra* etc.

The most significant feature of the phytodiversity of this plateau is the discovery of 9 new plant taxa since 1990 by different workers. Four new species were discovered from the seasonal pools of the plateau (Table 2; Fig. 2a - d) in addition to the five new taxa discovered from the surrounding soil covered areas and also from the rock surfaces (Table 3, Fig. 2e - i). Three of these 9 taxa were discovered from the present study (Pradeep and Pramod, 2013; Pramod *et al*., 2012).

The rich diversity shown by the pools can be attributed to the geological setting of the area together with the climatic characteristics acting on them. The area is characterized by high exposure to sunlight, daily thermal variation, high velocity winds (especially on sunny days), etc. Factors such as soil pH, moisture content, water holding capacity, soil and atmospheric temperature etc., which were monitored

Table 2. List of new species discovered from the seasonal pools of Madayippara Lateritic Plateau

Sl. No.	Species	Family	Authors	Year
1	*Rotala malabarica*	Lythraceae	Pradeep *et al*.	1990
2	*Nymphoides krishnakesara*	Menyanthaceae	Joseph & Sivarajan	1990
3	*Eriocaulon madayiparense*	Eriocaulaceae	Swapna *et al.*	2012
4	*Coelachne madayensis*	Poaceae	Pramod & Pradeep	2012

Table 3. List of new taxa discovered from Madayippara Lateritic Plateau other than from seasonal pools.

Sl.	Species	Family	Authors	Year
1	*Justicia ekakusuma*	Acanthaceae	Pradeep & Sivarajan	1991
2	*Lepidagathis keralensis*	Acanthaceae	Madhusoodanan & Singh	1992
3	*Lindernia madayiparensis*	Linderniaceae	Ratheesh Narayanan *et al.*	2012
4	*Parasopubia hofmannii*	Orobanchaceae	Pradeep & Pramod	2013
5	*Parasopubia hofmannii* var. *albiflora*	Orobanchaceae	Pradeep & Pramod	2013

Table 4. Average of microclimatic data of the seasonal pools and soil covered plots of the Madayippara lateritic plateau in different seasons

Parameters		Pre-monsoon		Monsoon		Post-monsoon	
		Seasonal pool	Soil areas	Seasonal pool	Soil areas	Seasonal pool	Soil areas
Temperature (Avg.°C)	Air	34.01	33.86	30.28	30.44	32.50	32.66
	Soil	46.82	45.9	33.89	33.78	43.31	43.07
	Water	-	-	34.72	-	-	-
Water pH (Avg.)		-	-	7.19	-	-	-
Soil pH (Avg.)		5.18	5.04	5.86	5.61	5.01	5.01
Soil Water Holding Capacity (Avg. %)		78.10	53.31	6.80	17.82	76.72	43.65
Soil Moisture content (Avg. %)		4.46	6.21	41.07	26.85	3.25	4.80

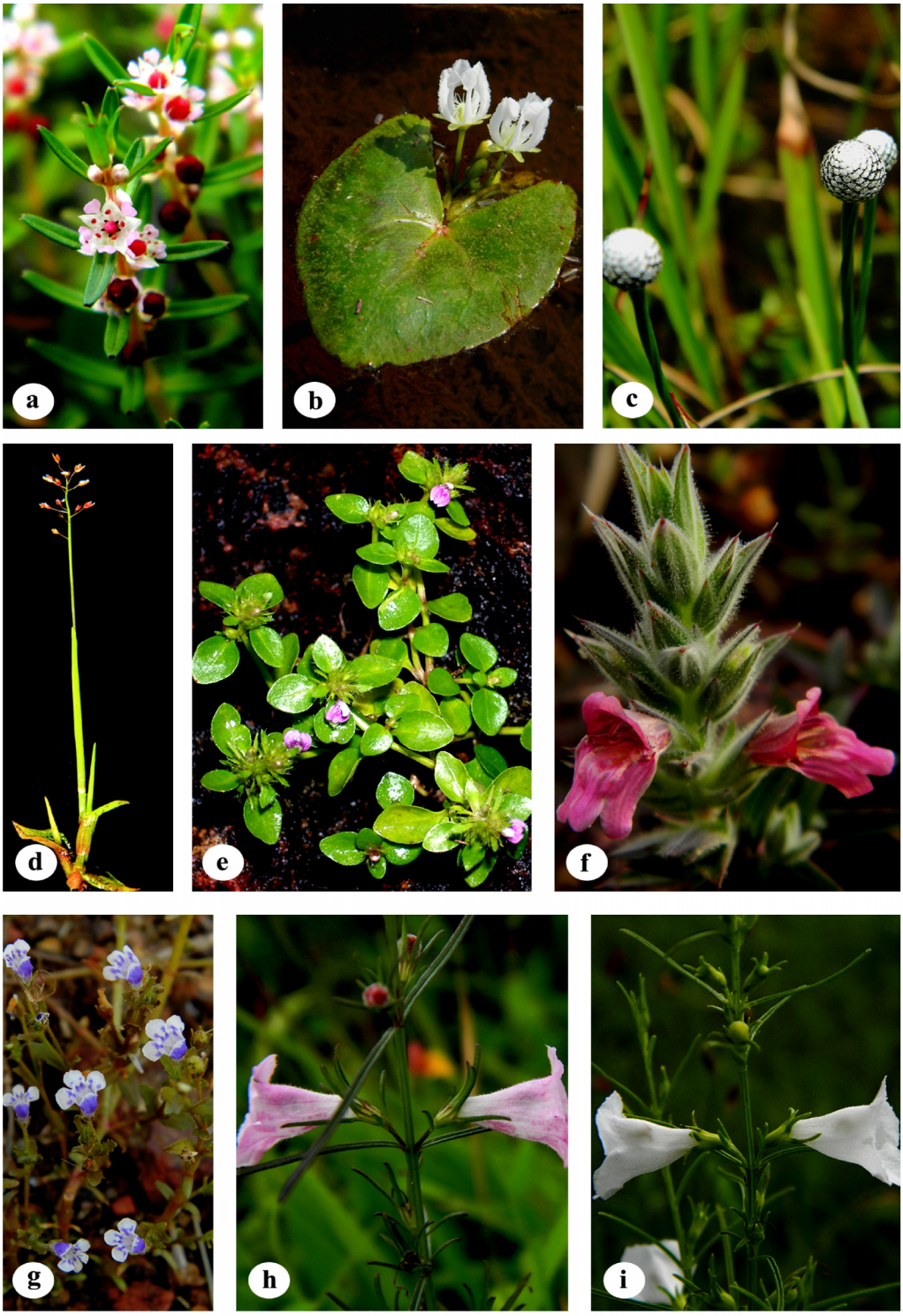

Fig. 2. a - d. New species discovered from the seasonal pools of Madayippara lateritic plateau; **a.** *Rotala malabarica;* **b.** *Nymphoides krishnakesara;* **c.** *Eriocaulon madayiparense* & **d.** *Coelachne madayensis*; **e** - **i**. new taxa discovered from other habitats of Madayippara lateritic plateau; **e**. *Justicia ekakusuma;* **f**. *Lepidagathis keralensis;* **g**. *Lindernia madayiparensis;* **h**. *Parasopubia hofmannii* var. *hofmannii* and **i**. *Parasopubia hofmannii* var. *albiflora*

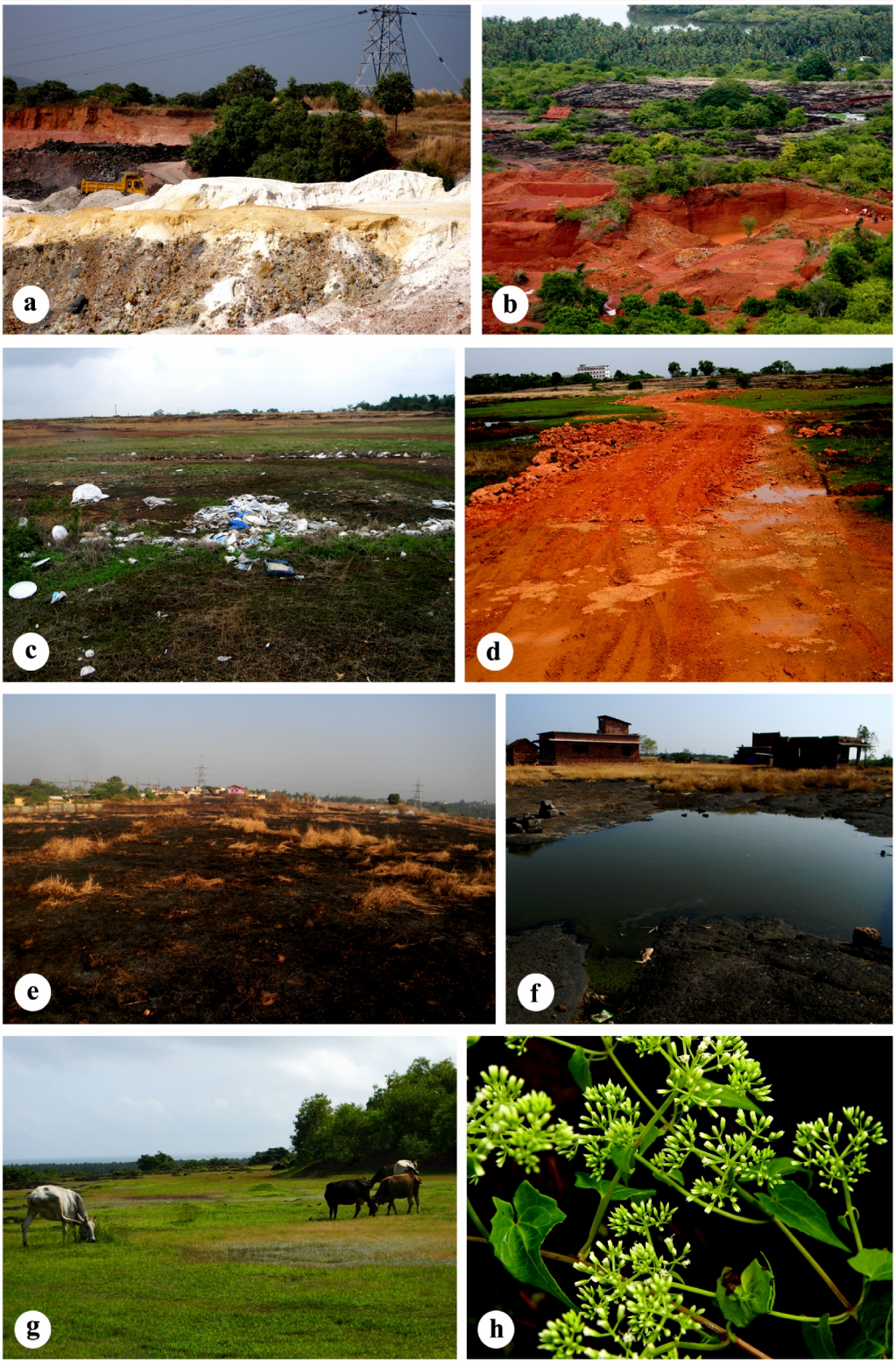

Fig. 3. a - h. Major threats to the habitats of Madayippara lateritic plateau; a. clay mining; b. quarrying; c. waste dumping; d. roads; e. seasonal fire; f. construction works; g. grazing & h. exotic weeds

periodically in the present study were also in conformity with the findings. The average pH of the soil in the seasonal pools are little higher than that of normal soil in wet season (Table 4). The water in the seasonal pools is slightly basic. Another major factor determining vegetation is the moisture content, the average values of which in the present study ranges from 3.25% to 42.07% between wet and dry seasons. The average values of water holding capacity also varied accordingly. The temperature of the soil also showed considerable variation, as a corollary of the moisture content.

As with many other similar habitats of Northern Kerala, the rich and diverse habitats of Madayippara are also subjected to varied types of anthropogenic pressures (Fig. 3a – h). Laterite and clay mining forms major threats in these habitats. The Kerala Clays and Ceramics Limited, a company under the control of Govt. of Kerala has mined out a major portion of the plateau in the southwestern side, and still planning to augment their mining activities, despite the protest from various environmental organizations in Northern Kerala. This plateau is also being traversed by a number of road networks, which also leads to considerable loss of plant diversity. Indiscriminate activities of the local travelers and antisocial elements also cause severe disturbances to these fragile ecosystems. Another major threat to the diversity of this area is the frequent fire that occurs in summer months. The encroachments for construction works in the plateau have started ruining the natural vegetation along its borders. Deposition of waste, invasion of exotic species and overgrazing by cattle also cause serious threat to the biodiversity. Geologically and ecologically important midland lateritic hillocks of Northern Kerala are slowly vanishing as the soil and rock are enormously scrapped off to meet the demand of land developers. The rich biodiversity together with the threats associated with the area reiterates the need for conserving the area on a war footed basis.

CONCLUSIONS

The study upon generalization reveals that Madayippara, like other lateritic plateaus of Northern Kerala, are rich in plant diversity due to its diverse micro-ecosystems. The flora of the plateau comprises mainly of ephemeral and seasonal herbaceous vegetation. The rich diversity associated with Madayippara has been least documented by Botanists and the ecosystem characteristics highly neglected by conversationalists. The lack of awareness on the conservation value of these habitats leads to varied types of anthropogenic disturbances like brick and clay mining, road and building constructions, land filling, seasonal fire *etc.* together with biotic pressures like invasion of exotic weeds. All these factors cause serious threat to the rich flora and fauna of these habitats and hence demands urgent attention from the part of policy / decision makers. It being the type locality of 9 angiosperm taxa, of which 3 are named after Madayippara, *in situ* conservation of the entire habitat is the only solution as *ex situ* conservation measures cannot provide complex microclimatic requirements artificially.

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