IUCN SSC FRESHWATER PLANT SPECIALIST GROUP

Development of a conservation plan for Malabar river-lily (*Crinum malabaricum*)

October 2017

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Cover image: Flower of Malabar River-lily (*Crinum malabaricum*) at the type locality near Periya Village

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EXECUTIVE SUMMARY

The Malabar river-lily (*Crinum malabaricum*) was described new to science in 2012 (Lekhak and Yadav 2012) and is endemic to four streams in Kasaragod and Kannur Districts in northern Kerala, south-western India. In 2016 it was assessed as critically endangered using the IUCN criteria; however this study has obtained and collected new information which shows that whilst still vulnerable, populations are fairly secure. This report describes the results of a study designed to describe and document the current population of *Crinum malabaricum*, the habitat on which it depends and any plausible threats to the known populations, to serve as a basis for monitoring and for any measures to protect the population; hold discussions with local people to assess their current relationship with *C. malabaricum* and the habitat on which it depends, as well as ways in which to enable this relationship to continue whilst resolving current pressures on the population and report on the work with recommendations for conservation of *C. malabaricum*.

Once new information on the distribution and status of *C. malabaricum* had been made available, the project aims were modified because it was clear that the most important action for conservation of *C. malabaricum* was to obtain baseline data from which analysis of population trends could be carried out. During the fieldwork for this project, we were lucky enough to be able to work with students from the second year botany course at the Government College, Kasaragod to collect such a baseline for the population at the type locality. The protocol employed was designed to measure both the overall trend in the population and to assess reproductive capacity. Two types of data were collected, a sketch map of main features of the stream and adjacent habitat, as well as indicating areas where stands of *C. malabaricum* exceeded 80% in the channel, together with quantitative data on the reproductive capacity of different stands of *C. malabaricum*.

The results of this survey have shown that the global population is in the region of 25,500 individuals, all of which occur within 20 km of the coast in four seasonal streams at around 100 m a.s.l. The reaches of the streams which support *C. malabaricum* are fairly level or gently sloping, 2-5 m wide and <1 m deep, with a gravel bed and fairly fast flow where *C. malabaricum* occurs, all arise on the laterite and *C. malabaricum* only occurs where the streams flow over the laterite. All the streams have been extensively modified by man, mostly with a 2-3 m high wall of laterite blocks along one or both margins, other significant modifications are mainly associated with road crossings. *C. malabaricum* is a major ecosystem architect, providing shelter for fish and invertebrate communities, dramatically modifying the hydrology of the streams and almost certainly playing an important role in nutrient cycling.

There are no obvious threats to the populations of *C. malabaricum* and the monitoring baseline established at Periya should, if extended to cover the other populations, enable measurement of population trends and a response should a decline become apparent. The Red List Assessment for *C. malabaricum* needs to be revised, probably to Vulnerable D2, based on the small number of populations.

C. malabaricum is only one of a large number of wetland-dependent plants species which are endemic to south-western India and particularly the Western Ghats. Most of the endemic wetland-dependent plant species occur in seasonal pools in laterite grassland and are threatened by habitat loss and degradation. There is an urgent need for a major initiative to stimulate and support conservation of wetland plants throughout the Western Ghats, to ensure conservation of these wetland-dependent plant species.

1 INTRODUCTION

The Malabar river-lily (*Crinum malabaricum*) was described new to science in 2012 (Lekhak and Yadav 2012) and reported to occur only in a seasonal stream in the vicinity of Periya Village, Kasaragod District in northern Kerala, south-western India. At the time it was considered to be restricted to a 500 m length of the stream, with a population estimated at approximately 1,000 individuals (Lekhak and Yadav 2012, Lansdown 2016). Subsequent information added that the species appeared to only occur where the stream was shaded under relatively closed canopies and that the integrity of the shading woodland was threatened by exploitation for firewood (K. Randall pers. comm. 2014). On the basis of this information, *C. malabaricum* was classed as Critically Endangered under the IUCN Criteria (version 3.1: IUCN 2016). Based on the information available at the time, this project was developed with the following aims:

- To describe and document the current population of *C. malabaricum*, the habitat on which it depends and any plausible threats to the known populations, to serve as a basis for monitoring and for any measures to protect the population.
- To hold discussions with local people to assess their current relationship with *C. malabaricum* and the habitat on which it depends, as well as ways in which to enable this relationship to continue whilst resolving current pressures on the population.
- To report on the work with recommendations for conservation of *C. malabaricum*.

During project development, contact was made with Biju P., Assistant Professor of Botany at the Government College, Kasaragod who has been surveying seasonal pools in the laterite inselberg formations in northern Kerala during the last ten years. In connection with these surveys he discovered another three populations of *C. malabaricum* in different streams, another one in Kasaragod District and two in Kannur District (Figure 1.1).

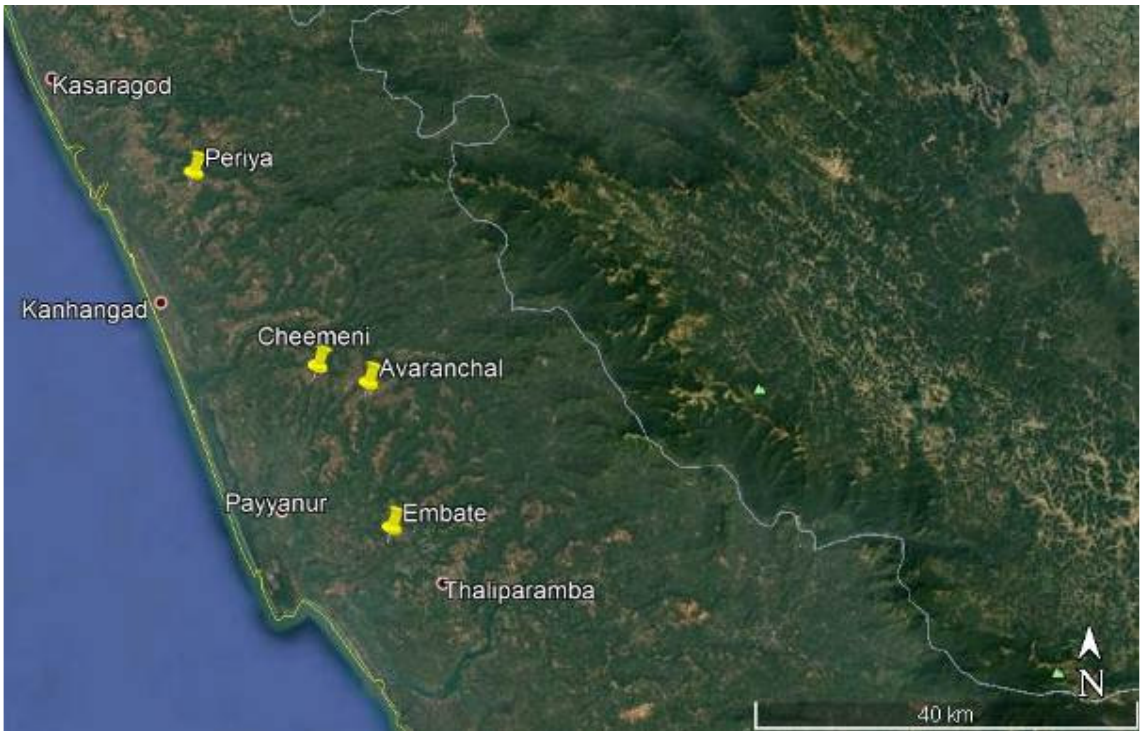

Figure 1.1 Map of the coast of north-west Kerala, showing the locations of the four known populations of *C. malabaricum* (source Google Earth)

This document describes the current state of knowledge of *C. malabaricum* and considers potential for future conservation work. Information is presented in three chapters following this introduction:

- A synthesis of available information on the distribution and ecology of *C. malabaricum*.
- A description of a monitoring baseline collected in 2017 and discussion of potential conservation action.
- A summary of the conclusions reached through the work described here.

Acknowledgements

We are profoundly grateful to Ranjith for his help and company during fieldwork. We would like to thank Biju P. for everything, including showing us the sites, translation, identification of aquatic and other plants, background data and particularly for making our baseline data collection possible. We are also grateful to Sijith Raghavan for bringing the students and helping both us and them with fieldwork. We would especially like to thank the students for their enthusiasm, interest and commitment, as well as for their long, hard work. This project was made possible by a grant from the Mohammed bin Zayed Species Conservation Fund for which we are profoundly grateful.

2 DISTRIBUTION AND ECOLOGY

2.1 Introduction

C. malabaricum is known to occur in four streams in the northern part of Kerala State in south-west India. All four of these sites were visited on the 25th-27th September 2017. Initial data collection involved a brief walk-over survey of readily accessible parts of each population, taking notes on the size of the population and talking to local residents about the context and any potential threats. Subsequently, a day was spent working with students from the Government College Kasaragod to collect a baseline for monitoring surveys (see chapter 3). In this chapter, we synthesise published and field data to describe the ecology of *C. malabaricum*. This is followed by a detailed description of each of the sites visited and details of the populations recorded.

2.2 Ecology

The streams where *C. malabaricum* has been recorded are separated by between 10 and 20 km and are tributaries of more than one and probably a total of three rivers. All four streams arise from the laterite, the populations occur in the middle sections of streams at around 100 m altitude and are within 20 km of the coast, in a belt of relatively low-lying hills, characterised by extensive laterite exposures. All of the streams supporting *C. malabaricum* are 2-5 m wide, with fast flowing water <0.5 m deep at the time of survey, except where the hydrology has been modified by man. All of the streams are seasonal, beginning to flow in May or June when the monsoon rains begin and flowing until January or February, when they dry out completely (Figure 2.1). The bed material associated with each population was gravel with material ranging from fine grit to small or even medium-sized stones, all of the streams include local silt deposits, where flow slows but these deposits did not generally support *C. malabaricum*. Laterite bedrock exposures dominate in the first stage of the streams but typically occur only as discrete patches in the middle and lower stages, where *C. malabaricum* occurred among these exposures, it grew in gravel deposits on the rock.

Figure 2.1 The stream at Periya, approximately 100 m upstream of the concrete banks associated with the footbridge in September 2017 (left) and in early February 2014 (photo K. Randall)

The streams in this area typically arise in springs on fairly steeply sloping ground, flowing for less than 1 km before the slope declines and the stream, although still fast-flowing, levels out and becomes stable for a distance of a few kilometres. Subsequently, the streams become broad and often slow-flowing before entering one of the larger rivers which take the water to the coast. *C. malabaricum* appears to be completely absent from the first and last stages of these rivers, but is abundant or dominant in the middle stage.

All of the streams supporting *C. malabaricum* have been modified by humans for some time; all were lined on at least one margin by a wall 2-3 m high of laterite boulders (Figure 2.12). It is notable that as soon as there is an intervention, such as use of the channel, modification of flow or disturbance of the banks, *C. malabaricum* becomes more sparse (gappy).

Figure 2.2 Two plants of *C. malabaricum* at Aravanchal, showing the dense leaves < 4 m long arising from a bulb buried in the gravel bed of the stream

C. malabaricum occurs at typically >80% cover in the channel, to the extent that it impedes flow (Figure 2.1), except for five situations:

- It occurs only as scattered plants among laterite outcrops which limit the channel such that flow is narrow and fast (Figure 2.3).
- Where local women enter the channel to wash clothes, creating gaps in the population (Figure 2.4), partly apparently as a consequence either of the disturbance but also partly by cutting plants.
- At a point, c 200 m upstream of the road bridge, where the banks have been completely replaced by concrete and a partial dam installed beneath a foot-bridge (Figure 2.6), as a consequence the water is deep and flow slow. There is also point c 100 m downstream of the road bridge where flow is deep and slow and *C. malabaricum* largely absent, it is likely that the change in flow and consequent absence of *C. malabaricum* are due to artificial modification of the channel.
- Where the canopy is so dense that no natural light reaches the channel.
- Immediately up- and downstream of bridges.

The occurrence of a large plant such as *C. malabaricum* in small water courses where its own growth significantly modifies the hydrology progressively as water levels decline and the streams dry out is unusual, echoed only by species such as *C. thaianum* in Thailand (Pradissan and Pipatcharoenchai 2008) and the larger *Ranunculus* Sect. Batrachium taxa in Europe (Lansdown 2007), although both of these typically occur in larger water courses. It is possible that this high density is important for the survival of *C. malabaricum* populations and almost certain that *C. malabaricum* can be considered an ecosystem architect and keystone species where it occurs. Pradissan and Pipatcharoenchai (2008) note the importance of *C. thaianum* for fish and anecdotal observations suggest that there is a strong association between *C. malabaricum* and fish communities.

The sheer size of the plants and the density at which they occur mean that as the water level drops and the streams ultimately dry out, the plants initially force flow into narrower pathways within the channel and then represent a massive quantity of degrading vegetation which must have implications for the nutrient status of the bed material. The process of degradation of the plants is aided by grazing caterpillars, tentatively identified as the larvae of the Indian Lily-moth (*Polytela gloriosae*) (Figure 2.7) which can occur in very large numbers and completely graze out large populations before the streams dry out completely.

Figure 2.3 Scattered plants of *C. malabaricum* growing where laterite exposures create broken, fast flow

Figure 2.4 A local resident washing clothes in the channel in the upstream reaches of the stream at Periya which students collect baseline monitoring data. The gap in the *C. malabaricum* population resulting from regular access to the channel can clearly be seen, as can the extent of the influence of this activity

Figure 2.5 A gap in the *C. malabaricum* population (between Dr. Raghavan and the group of students) caused by local residents entering the stream to wash clothes

Figure 2.6 The highly modified section of the stream upstream of the footbridge and partial dam, showing deep slow flow in an area with only a few scattered plants of *C. malabaricum*

Figure 2.7 Caterpillar of the Indian Lily-moth (*Polytela gloriosae*) feeding on *C. malabaricum*

Figure 2.8 *C. malabaricum* at Embate, showing two inflorescences, one with a number of buds

Figure 2.9 Mature fruit of *C. malabaricum*, adjacent to an inflorescence with immature fruit

Plants grown in permanent standing water in the Malabar Botanical Garden in Kozhikode (Calicut) have survived for a few years but in declining condition (R. Prakashkumar pers. comm.), whereas plants transplanted to a laterite stream north of Periya have survived (Biju P., pers. comm.). This would seem to suggest that either flow or seasonality or both are necessary for survival of this species and that dispersal is a constraint on population size.

All four populations included flowering plants (at the Periya population, approximately 1: 5 plants had inflorescences in sections surveyed) and a fairly high proportion of these produce fruit which expand and appear to ripen (Figure 2.9). However, it seems likely that as noted previously, plants propagate mainly by vegetative means where a mother bulb gives rise to many smaller bulbs, visible as clusters of bulbs growing in the stream (Lekhak and Yadav 2012). It may be that seed set is important mainly when some factor creates a gap in a population.

All four populations showed a succession of flowering, from inflorescences in which the buds had yet to develop, through open flowers to fully mature fruit. From the different stages of development of the flowering parts seen during surveys, it would appear likely that the process from initiation of the inflorescence through to ripening of the fruit is likely to take at least a few weeks and probably a month. Thus, it is reasonable to conclude that *C. malabaricum* flowers at least from early September until the end of October.

2.3 Periya, Kasaragod District

Location: 12° 24.526' N, 75° 06.571' E, 102 m a.s.l.

Population

This is the type locality and best known of the sites, it was also the focus of the monitoring baseline collected in September 2017 (see Chapter 3). *C. malabaricum* occurs over a length of at least 700 m upstream of the road bridge and 400 m downstream, possibly with a maximum length for the population of 1400 m (Figure 2.10). Counts taken from areas of dense growth ranged from 45 plants in 10 m, where the channel was narrowed by laterite exposures, to 130 plants in 10 m at a point where the channel was broad and of even depth, with an average of about 80 plants in 10 m. Taking into account gaps of 100 m downstream and 50 m upstream of the road bridge, c 150 m associated with the partial dam and footbridge, together with an estimated total of 100 m of gaps due to washing pools and laterite outcrops, the total population of *C. malabaricum* in this population can be estimated to be 8,000 plants. More detail on the composition of the population is provided in Chapter 3.

Figure 2.10 The stream (blue) at Periya which supports *C. malabaricum*, the area where *C. malabaricum* occurs in dense stands is marked in yellow

Adjacent habitat

The stream arises on higher ground approximately 2 km east of the road bridge at the coordinates given above (east of the eastern limit of the blue line in Figure 2.10). Initially it flows through secondary vegetation and open laterite grassland before dropping down through gardens to a section with rice fields on either side, at which point *C. malabaricum* starts to occur as scattered plants. Downstream to the road bridge, the land alongside the stream generally holds a combination of coconut and Areca Nut plantations (Figure 2.11) and gardens which include coconuts but also have a range of fruit and ornamental trees. Throughout this section, *C. malabaricum* typically occurs at ≥80% cover apart from particular situations (see Ecology, above). Immediately upstream of the road bridge, there is a short area of secondary growth where *C. malabaricum* is sparse. For approximately 100 m downstream of the road bridge, the stream flows through open grassland and secondary scrub where *C. malabaricum* is very sparse or absent, before entering a coconut plantation where it is again abundant to dominant. The downstream end of the population was not mapped precisely, but there was no evidence of the population at a point approximately 1 km downstream of the road bridge.

Associated species

At this site, upstream of the road bridge for c 300 m and downstream of the road bridge, the channel also supports a wide range of aquatic species, including *Blyxa aubertii* var. *echinosperma*, *Eriocaulon heterolepis*, *E. kanarense*, *E. setaceum* and *Lymnophyta aquatica*, in the area immediately upstream of the footbridge, where water is ponded by a weir, these species occur in abundance with a fine-leaved *Najas* sp.. Throughout this area, the margins also support *Isachne globosa*, *Sasiola pisinterrupta* and *Oryza rufipogon*. Upstream of this area where the stream flows through fairly dense shade, *C. malabaricum* is the only species occurring in the channel. Upstream of this, particularly where the channel includes laterite outcrops, there are extensive stands of *Eriocaulon kanarense*, with grasses where soil collects. *Cryptocoryne spiralis* var. *caudigera* was recorded at the site by K. Randall in 2014.

Threats

There are no obvious and immediate threats to the population of *C. malabaricum* or associated habitats at Periya. The perceived threat of cutting streamside trees does not appear to be real. Not only are streamside trees not obviously used for firewood, but *C. malabaricum* does not appear to be dependent upon a closed canopy. It is likely that the main action directly affecting *C. malabaricum*; clearing or suppression of patches where local people use the stream, has been happening for a long time and does not appear to have any significant effect on the overall population. However it is clear that interventions such as the installation of concrete walls (as opposed to the laterite

block walls traditionally used) have a dramatic adverse effect on populations and no further interventions of this nature should be permitted.

Figure 2.11 The stream at Periya, flowing through Areca Nut (right) and coconut (left) plantations, with *C. malabaricum* at 100% cover through the channel

2.3 Embate, Kannur District

Location: 12°04'26.1" N, 075°18'22.2" E, 82 m a.s.l.

Population

The population at Embate was not surveyed in full but a length of approximately 200 m of the stream was surveyed. One of the landowners told us that *C. malabaricum* does not occur within 1 km of the source, but is abundant for 2-3 km before the stream widens, becoming deeper and slower-flowing, this estimate was not verified. Along the section surveyed, *C. malabaricum* achieved cover values similar to or possibly slightly lower than those at Periya. A conservative population estimate, assuming cover of 60 individuals per 10 m over a length of 2 km would suggest that this population could involve approximately 12,000 individuals. Even if this is an exaggeration, it is clear that the population at Embate is very large.

Figure 2.12 Flowering and fruiting *C. malabaricum* in the stream at Embate, showing the laterite block wall

Adjacent habitat

The banks throughout much of the stream section visited had been modified by installation of laterite blocks to form a wall 2-3 m high (Figure 2.13). Beyond this, the adjacent land was characterised by a sparse settlement with gardens and coconut plantations.

Associated species

The stream at Embate contains very few species of plant in the section visited, *C. malabaricum* was the most abundant species, apparently to the exclusion of other plants. Where flow was broken or faster (such as along a section narrowed by hard banks on both sides), other species such as *Eriocaulon kanarense*, *E. heterolepis* and *Limnophila repens* became dominant and *C. malabaricum* very sparse (Figure 2.13).

Figure 2.13 Narrow section of the stream at Embate with walls on both margins, *C. malabaricum* is sparse, while *Eriocaulon heterolepis* and *E. kanarense* are abundant

Threats

According to one of the adjacent landowners, there has been a decline in the population of *C. malabaricum* in the stream following bank strengthening and possibly also related to clearing the stream for gravel, which has been represented by more gaps appearing between plants.

2.4 Aravanchal, Kannur District

Location: 12°12'34.3" N, 075°17'02.3" E, 100 m a.s.l.

Population

Only a very small proportion of this site was visited. The population seen was sparse toward the upstream end as the stream flows over laterite exposures, but downstream of these immediately becomes dense, reaching 100 % cover (Figure 2.14). It is not possible to provide a meaningful estimate of the total population, but the parts surveyed involved at least 500 individuals.

Adjacent habitat

The stream arises within a stand of native forest which is protected as a Sacred Grove, downstream of this the stream passes through coconut and Areca nut plantations. Beyond these, the land to the south is mainly characterised by extensive species-rich laterite grassland.

Associated species

The only species occurring in the water with *C. malabaricum* at this site were *Eriocaulon kanarense* and *E. heterolepis*.

Threats

The land alongside then sacred grove and extending some way downstream has been assigned to housing development which represents a significant risk to this population, arising from risk of direct damage, run-off causing sedimentation and untreated waste entering the water course.

Figure 2.14 *C. malabaricum* at Aravanchal, showing the upstream part of the population among laterite exposures and the lower part reaching high density on the bend

2.5 Cheemeni, Kasaragod District

Location: 12°13'31.2" N, 075°14'06.7" E, 93 m a.s.l.

Population

The population of *C. malabaricum* seen at Cheemeni was between the road bridge and the first house downstream of this. A visit was made downstream of this house and no *C. malabaricum* was seen, although it is possible that there were further stands downstream of this or even upstream of the road. Throughout the section surveyed, *C. malabaricum* occurred at very high density, typically ≥80 % cover except for a 20 m section downstream of the road bridge and a gap where people cross the stream. The length of stream supporting dense populations was approximately 500 m and it is not unreasonable to estimate a population density of 100 plants per 10 m section (through comparison with stands documented at Periya). Therefore, the population recorded at Cheemeni may be estimated at 5,000 individuals.

Adjacent habitat

The section of stream surveyed at Cheemeni was bounded on both sides by a rubber plantation with dense ground cover (Figure 2.15). It is of note that this is the only stream section supporting *C. malabaricum* during this project which had not been modified in the past by installation of a wall along one bank. Beyond the rubber plantation land was given over to improved pasture and disturbed ground supporting ruderals.

Figure 2.15 The stream flowing through the rubber plantation at Cheemeni, showing a gap in the C. malabaricum where a track crosses, but dense cover further downstream

Associated species

No other species were recorded in the stream along the section supporting *C. malabaricum*.

Threats

It is likely that management of the rubber plantation could result in siltation of the stream, probably combined with nutrient enrichment due to fertiliser application and possibly leaching of pesticides. However, the condition of the *C. malabaricum* population throughout the plantation appears very good and it is possible that the species will be able to survive in this situation. It will be very important to monitor population trends at this site to ensure that management of the rubber plantation is not having an adverse impact.

4 POTENTIAL FOR CONSERVATION AND MONITORING

4.1 Monitoring

During fieldwork, the opportunity arose to establish a baseline data-set to monitor trends in the population of *C. malabaricum* near Periya. On the initiative of Assistant Professor Biju P. and Dr. Sijith Raghavan of the Government College, Kasaragod in northern Kerala a total of fifteen students from the 2nd year botany course visited the site, taking the opportunity both to collect a baseline and provide the students with field recording experience.

Figure 3.1 Two students mapping the channel and distribution of *C. malabaricum* while other students walk upstream after documenting a 10 m section of dense *C. malabaricum*

The protocol employed was designed to measure both the overall trend in the population and to assess reproductive capacity. Two types of data were collected:

1. A sketch map was prepared showing the main features of the stream and adjacent habitat, as well as indicating areas where stands of *C. malabaricum* exceeded 80% in the channel. First, surveyors calculated the number of paces required to walk 10 m on the stream channel or margin. Then each 100 m length of the stream was walked using 10 m paced lengths to provide a reasonably accurate indication of the location of features.

2. Precise details were recorded on 10 m lengths of each stand of *C. malabaricum* which exceeded 80 % cover in the channel, recording:

    - The total number of plants.
    - The number of flowering plants.
    - The number of inflorescences in bud.
    - The number of inflorescences with open flowers.
    - The number of inflorescences with immature fruit.
    - The number of inflorescences with mature fruit.

These methods were applied to a total length of 1100 m of the stream, representing most of the section supporting *C. malabaricum*.

Figure 3.2 A team of students collecting a detailed record of the population and reproductive capacity of *C. malabaricum* on a 10 m section of the stream (left) and Sanjay Molur photographing raw data sheets to obtain a preliminary back-up of the data (right)

The maps will be copied by hand using black ink with the aim of retaining maps which can be photocopied and taken into the field on subsequent monitoring visits to enable direct comparison. The results of the detailed recording will be tabulated to provide average measures for each of the parameters recorded.

The aim is that this monitoring record should be repeated at least once in five years at each of the four sites and ideally more often. It would be possible each year for students from the second year botany course at the Government College, Kasaragod to visit one of the four known *C. malabaricum* populations to collect this sort of data.

4.1 Conservation

Due to the work of Biju P., it is clear that *C. malabaricum* is in much better conservation condition than was thought to be the case. However, there is no doubt that it must still be considered to be vulnerable. Any one of the populations could be lost to a single event, such as inappropriate hydrological management of the streams where they occur. Thus, it is important to consider the potential for action to ensure that not of the populations is damaged. However, *C. malabaricum* is not the only wetland-dependent plant species endemic to the Western Ghats. In fact this region is one of the greatest centres of endemism for wetland-dependent plants in the world, with hundreds of threatened endemic species. While some of these, such as *Eriocaulon kanarense* occur in streams with *C. malabaricum*, many of the most vulnerable species occur in seasonal pools in laterite grasslands. Grassland habitats are typically considered to be "wasteland" by local residents and administrative organisations, as a result these habitats are particularly vulnerable and constantly being lost. Thus, there is an urgent need to attempt to address the conservation needs of a whole suite of species across the region, rather than focussing on a single species.

With regard to action specifically for *C. malabaricum*, it has been shown that *ex-situ* conservation in standing water systems is unlikely to be effective, but that transplantation to other seasonal streams in the area could work. This is

not an action that should be undertaken without careful consideration because successful introduction of *C. malabaricum* could have a dramatic and overwhelming effect on a stream, with possible significant adverse effects on the ecology of the stream and species which it supports. In fact, given the apparently healthy condition of the known populations, there is no obvious immediate need for *ex-situ* conservation, it is far more important to try to ensure the continued survival of the known populations.

All flowing waters in India are owned by the state and this is taken to include the bed of the watercourse. In contrast, the banks are owned privately and can apparently be modified without any form of planning control. Clearly, although the actions which appear to have had the greatest effect on existing populations have involved large-scale modification of the streams such as works associated with the footbridge at Periya which completely altered the vegetation (Figure 3.3), there is also potential for small-scale local works to damage *C. malabaricum* populations. The most effective way to avoid such damage is to ensure that local residents are aware of the species and its conservation importance, as well as understanding that their actions could have a dramatic adverse effect on it. The first steps toward informing local people about the species have been achieved, initially through visits by foreign botanists such as Karen Randall and more recently through the involvement of the students from Government College, Kasaragod in the monitoring. The lecturers and students from the college have the best potential to communicate the conservation message to local people and this should become part of the annual monitoring work.

Figure 3.3 Two views of the deep, more or less standing water upstream of the partial dam and footbridge at Periya, causing complete modification of the vegetation and a significant gap ion the population of *C. malabaricum*

One of the most important actions needed to enable protection of wetland-dependent sites, habitats and species in the region is to establish a sound scientific information baseline toward designation as sites of conservation importance. The conservation status of more than 600 freshwater wetland-dependent plant species occurring in the Western Ghats has been assessed using the IUCN Red List Criteria. Over the last ten years Biju P. has documented the vegetation of more than 600 seasonal ponds on the laterite toward submission of a PhD thesis in 2018. This work has therefore already provided much of the information necessary to inform conservation of these sites and habitats. Most of the Red List assessments were completed in 2010 and there is a need for these to be repeated in 2020 to include new data collected since the first assessments. Site and habitat-specific data need to be compiled into a document which provides explicit and detailed recommendations for formal recognition of priority areas for conservation of wetland-dependent plants in the region to inform local and regional administrative organisations.

This work should involve collaboration between Zoo Outreach Organisation, Malabar Botanical Garden and Government College Kasaragod supported by IUCN.

Action to protect specific sites in the short term, to ensure that they are not lost whilst the long-term conservation work is developed could include purchase of these areas when they become available and this is particularly relevant to the site at Avaranchal which is threatened by conversions of adjacent laterite grassland to housing. This would effectively prevent any development of the habitats and ensure long-term protection. The aim of this purchase would be to establish a field research centre in the area on the purchased land, thereby maintaining a presence of conservation oriented work in the area, promoting conservation of seasonal wetlands and the streams by direct local action and potentially involving local people in conservation of these habitats.

5 CONCLUSIONS

- Population estimates based on detailed recording of the population at Periya suggest that the global population is in the region of 25,500 individuals as follows: Avaranchal 500, Cheemeni 5,000, Embate 12,000 and Periya 8,000 individuals.
- *C. malabaricum* occurs within 20 km of the coast in four seasonal streams at around 100 m a.s.l. in northern Kerala: Periya and Cheemeni in Kasaragod District and Embate and Avaranchal in Kannur District. The stream reaches where *C. malabaricum* occurs are fairly level or gently sloping 2-5 m wide and <1 m deep, with a gravel bed and fairly fast flow. They all arise on the laterite and *C. malabaricum* only occurs where the streams flow over the laterite.
- *C. malabaricum* typically forms dense stands covering the entire channel with leaves which form a dense mat as water levels drop but which are ultimately grazed off by the caterpillars of the Indian Lily-moth.
- All four streams have been extensively modified by man, mostly with a 2-3 m high wall of laterite blocks along one or both margins, other significant modifications are mainly associated with road crossings.
- Where there are significant interventions, such as major crossings or sites where people regularly use the channel, this cause gaps in the stands of *C. malabaricum*.
- *C. malabaricum* thrives in relatively fast-flowing water but appears unable to survive in standing water.
- The success of plants introduced into a stream from which this species had never previously been recorded suggests that dispersal may be a limiting factor on population size.
- *C. malabaricum* flowers and appears to set seed abundantly from early September to late October.
- *C. malabaricum* populations occur in reaches of streams which flow through a range of habitats from relatively open gardens, through Areca nut, coconut and rubber plantations to dense scrub and woodland, although it appears not to tolerate a completely closed canopy.
- *C. malabaricum* typically occurs with species such as *Eriocaulon heterolepis* and *E. kanarense* and where the canopy is more open, other species may occur, such as *Blyxa aubertii* var. *echinosperma*, *Limnophila repens* and *Lymnophyta aquatica*, with grasses such as *Isachne globosa*, *Oryza rufipogon* and *Sasiola pisinterrupta* on the margins.
- *C. malabaricum* is a major ecosystem architect, providing shelter for fish and invertebrate communities, dramatically modifying the hydrology of the streams and almost certainly playing an important role in nutrient cycling.
- There are no obvious threats to the populations of *C. malabaricum* at Cheemeni, Embate and Periya the monitoring baseline established at Periya should, if extended to cover the other populations, enable measurement of population trends and a response should a decline become apparent. The population at Avaranchal is threatened by destruction of adjacent laterite grassland for housing and there is a need for action there.
- The Red List Assessment for *C. malabaricum* needs to be revised, probably to Vulnerable D2, based on the small number of populations.
- There is a need for a major initiative to stimulate and support conservation of wetland plants throughout the Western Ghats, to ensure conservation of the species and other taxa endemic to the region.

REFERENCES

IUCN. 2016. The IUCN Red List of Threatened Species. Version 2016-1. Available at: www.iucnredlist.org. (Accessed: 30 June 2016).

Lansdown, R.V. 2007 The identity of *Ranunculus* subgenus Batrachium in the River Itchen. Environment Agency, Southern Region.

Lansdown, R.V. 2016. Crinum malabaricum. The IUCN Red List of Threatened Species 2016: e.T69726391A69727184. http://dx.doi.org/10.2305

Lekhak, M.M. and Yadav, S.R. 2012. *Crinum malabaricum* (Amaryllidaceae), a remarkable new aquatic species from Kerala, India and lectotypification of *Crinum thaianum*. *Kew Bulletin* 67(521-526).

Pradissan, R. and Pipatcharoenchai, W. 2008 Biology of onion plant, Crinum thaianum Schulze: Technical paper no. 65/2008. Aquatic Plant and Ornamental Fish Research Institute, Department of Fisheries, Bangkok, Thailand.