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Introduction to the pitcher plants (*Nepenthes*) of Cambodia

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សេចក្តីសង្ខេប

រុក្ខជាតិបំពង់ស្រមោច (pitcher plants) នៃពួក *Nepenthes* (អំបូរ *Nepenthaceae*) នៅប្រទេសកម្ពុជាគឺមានការយល់ដឹងតិចតួចណាស់។ អត្ថបទនេះពិពណ៌នាពីការស្រាវជ្រាវថ្មីៗទាំងអស់នៃរុក្ខជាតិនៅក្នុងពួកនេះនៃប្រទេសកម្ពុជា។ វាពិពណ៌នាសង្ខេបលើប្រវត្តិរុក្ខជាតិនៃពួកនេះប្រទេសកម្ពុជា និងបង្ហាញការសង្ខេបចំណាត់ថ្នាក់ប្រភេទតាមលក្ខណៈវិទ្យាសាស្ត្រ ដែលរួមបញ្ចូលនូវការធ្វើចំណាត់ថ្នាក់ថ្មីៗមួយដើម្បីស្គាល់ប្រភេទនោះ។ អត្ថបទនេះផ្តល់ឱ្យនូវការយល់ច្បាស់ទៅលើលក្ខណៈអេកូឡូស៊ីនៃពួកទាំងនេះ របាយ និងការអភិរក្សរបស់ពួកវានៅក្នុងប្រទេសកម្ពុជា។ ថ្វីបើមានការបោះពុម្ពផ្សាយថ្មីៗមួយចំនួនក៏ដោយ ភាពចម្រុះ និងភាពផ្សេងៗគ្នានៃពួក *Nepenthes* ប្រទេសកម្ពុជានៅមានការយល់ដឹងតិចតួច និងជាសំខាន់ទាមទារឱ្យមានការសិក្សាស្រាវជ្រាវបន្ថែមទៀត។

Abstract

The pitcher plants of the genus *Nepenthes* (*Nepenthaceae*) in Cambodia are poorly known. This article discusses all of the recent research on this genus in Cambodia. It outlines the botanical history of the Cambodian taxa and presents a taxonomic summary that includes a key to the currently recognised taxa. The paper also provides insights into the ecology of the genus, its distribution, and its conservation status on Cambodian territory. Despite a number of recent publications, the diversity and variability of the genus *Nepenthes* in Cambodia remain poorly understood and require significant further research.

Keywords

Cambodia, carnivorous plants, conservation, Indochina, *Nepenthes*, taxonomy.

Introduction

As a result of past internal and international conflicts, Cambodia’s borders have long been closed to researchers. It was only in the late 1990s that scientists were able to begin investigating Cambodia’s biological diversity in earnest. Now, thanks to the increased efforts of local and international scientists, Cambodia is revealing its diverse flora and fauna. Even so, the documentation of biodiversity in Cambodia is still in its infancy (Daltry, 2008) and, without doubt, many species remain to be described (Ashwell, 1997). Data on the flora of Cambodia are particularly scant. The number of plant collections has risen steadily in the past decade, but owing to a lack of research and literature, hundreds of specimens remain unidentified (Daltry, 2008).

Cambodia is the home of several species of carnivorous plants. These attract, capture, kill and digest prey using modified leaves that act as traps (Lloyd, 1942). This group of plants, which is currently composed of approximately 720 known species divided among 11 families and 19 genera (McPherson, 2010), is represented in Cambodia by three genera in three different families: the sundews *Drosera* L. (*Droseraceae*), the pitcher plants *Nepenthes* L. (*Nepenthaceae*) and the bladderworts *Utricularia* L. (*Lentibulariaceae*). Carnivorous plants from the countries of the Indochinese Peninsula - namely Cambodia, Laos, Thailand and Vietnam - have received little attention from researchers in comparison to those from other parts of the world, such as Australia, the Malesian region, South Africa

and the Americas, where many species have been studied and described (McPherson, 2010). The literature on Cambodian carnivorous plants is particularly scarce and has not been updated in recent times. Most records date back to colonial times, from the end of the 19th Century to the early 20th Century (Mey, 2009).

Although the spectacular genus *Nepenthes* (commonly known as the ‘tropical pitcher plants’, ‘Asian pitcher plants’, ‘monkey cups’, or ‘Ampueng Sramoch’ and ‘Ampueng Kralôm’ in the Khmer language) has been the subject of several papers in recent years (Cheek & Jebb, 2009; Mey, 2009; Holden, 2010; Mey *et al.*, 2010), only a relatively small part of Cambodian territory has been prospected. Significantly more surveillance work is needed to develop a full understanding of the diversity and the distribution of *Nepenthes* in Cambodia. In the same fashion, though to a greater extent, the relatively inconspicuous carnivorous plant genera *Drosera* and *Utricularia* also require further in-depth study.

Most of Cambodia’s carnivorous plants are adapted to the strongly seasonal Indochinese climate, which is roughly divided into wet and dry seasons. Indochina is subject to the influence of monsoons with seasonal rainfall patterns: the dry season begins in November or December and lasts until April or May (Anon., 2006). While most carnivorous plants worldwide occur in relatively wet habitats, species of the Indochinese Peninsula have adapted to the seasonal droughts. Four of the five known Cambodian species of *Nepenthes* are regarded as pyrophytes: these taxa have the ability to survive in seasonally dry savannahs or semi-deciduous monsoon forests, which are prone to dry season fires, due to their development of water storage organs in the form of a fleshy rootstock (Mey *et al.*, 2010).

The carnivorous plants in the other two genera have developed their own ways to survive the Indochinese climate. One of the sundews, *Drosera peltata* Thunb., produces a tuber typical of the tuberous *Drosera* species within the section *Ergaleium*. This allows the plant to survive the dry season in a

dormant state. The other two Cambodian sundews, *D. indica* L. and *D. burmanni* Vahl, are annual species that endure the drought as seeds (McPherson, 2008). Several of the bladderworts, including *U. caerulea* L. and *U. bifida* L., are also annual (Taylor, 1989).

The genus *Nepenthes* currently includes 129 known species worldwide, with the islands of Borneo, Sumatra and the southern Philippine archipelago considered to be the *Nepenthes* centres of diversity (Danser, 1928; McPherson, 2009). They host 36, 37 and 24 species respectively (McPherson, 2009; 2010). In comparison, only five species are known from Cambodia and 14 from the four countries of the Indochinese Peninsula. Of these, nine species are thought to be so closely related that they have been ascribed to a single group, the *Nepenthes thorelii* aggregate (Mey *et al.*, 2010).

Botanical history of the Cambodian species

In 1909, botanist Paul Henri Lecomte published an account on the species of French Indochina – Cambodia, Laos and Vietnam – in which he described three taxa: *Nepenthes thorelii* Lecomte, from Vietnam, and *N. kamptoniana* Lecomte and *N. geoffrayi* Lecomte from Kampot Province in Cambodia (Lecomte, 1909). For a long time, Lecomte’s publication and its successor - the *Flore Générale de l’Indo-Chine* (Lecomte, 1946) - were the only substantial literature on the *Nepenthes* of this area.

There has since been a striking lack of research on the Indochinese Nepenthaceae, which is explained by several factors. Most significant is the great internal and international conflicts that have affected many of these countries, leading them to close their borders for long periods. Furthermore, most of the type specimens for this region are comprised of fragmented material that is difficult to study and, given the superficial similarity of some species to one another, a great deal of confusion has developed. It has, for instance, recently been revealed that one of the Vietnamese taxa, *N. thorelii*, was described from mixed material belonging to

a number of different Indochinese taxa, including one Cambodian taxon (Mey, 2009, 2010).

The *Nepenthes* of Indochina have recently received significantly more attention, making up for a century of critically lacking research. This has included an account about the enigmatic *N. thorelii* (Mey, 2010), a Vietnamese taxon which may also occur in Cambodia (see below) and the description of several new taxa, namely *N. bokorensis* Mey, *N. holdenii* Mey (Mey, 2009, Mey *et al.*, 2010) from Cambodia; and *N. thai* Cheek (Cheek & Jebb, 2009), *N. andamana* M. Catal., *N. chang* M. Catal., *N. suratensis* M. Catal., *N. mirabilis* (Lour.) Druce *var. globosa* M. Catal. and *N. kerrii* M. Catal. & T. Kruetr. from Thailand (Catalano, 2010).

Identifying the Cambodian species

Nepenthes are long lianas that usually climb among neighbouring shrubs or trees, but can also scramble along the ground. They produce highly specialized leaves: at the end of the leaf blade (the normal-looking leaf) arises the pitcher, which is connected to the leaf blade by a thin tendril. The pitchers are seasonal in some species. In Cambodia, pitcher production is low during the dry season, making it difficult for the untrained eye to recognise a *Nepenthes* plant.

The pitcher has an oblique mouth which is overhung by a lid. The edge of the pitcher 'mouth' bears a ridge of hardened tissue: a finely ribbed structure commonly called the peristome. There are many nectar glands on the underside of the lid and their size, nature and distribution are of some taxonomic importance. Some appendages can also be found on the lower surface of the lid, either at the base of the midline or at the apex. The pitcher cup, which sometimes has a pronounced hip, is divided into two distinct zones. The upper part is called the "waxy zone" because its surface is covered with wax plates, while the "digestive zone", in the lower part of the pitcher, is covered with digestive glands and contains fluid.

When collecting and studying *Nepenthes*, it is crucial to take into account the dimorphism of the pitchers. Like most of their counterparts from other countries, Cambodian *Nepenthes* produce two different types of pitchers. These are commonly referred to as lower (or terrestrial) and upper (or aerial) pitchers. The lower pitchers lie on the ground and are usually squat and colourful. Most Cambodian *Nepenthes* produce reddish lower pitchers. There are two fringed wings on the front of this type of pitcher. The upper pitchers usually lack wings (they are reduced to two thin ribs), and are more elongated and infundibular (Clarke, 2001; Jebb & Cheek, 2001). The size and shape of the peristome, the nature of its inner margin, the gland size and their distribution on the lower surface of the pitcher lid provide important diagnostic characters. Botanists are strongly advised to press specimens so that the leaf petiole insertion, which provides important diagnostic characters, is clearly visible. The leaf shape, the number of longitudinal veins and the indumentum are also helpful.

Because *Nepenthes* is an entirely dioecious genus, it is also advisable to collect both male and female plants, or at least inflorescences from the same locality, although in the vast majority of Indochinese taxa, both sexes develop very similar inflorescences (Jebb, 1991; Jebb & Cheek, 1997, 2001).

Cambodia's *Nepenthes* flora can be divided into two informal groups. The first group consists of *N. mirabilis* only, a species which can be easily identified thanks to its petiolate leaves. The other group consists of the four species that comprise the *N. thorelii* aggregate. The species of this aggregate are similar in overall appearance and share many features: inflorescences that take the form of long thyrsoid panicles which are 1- or 2-pedicellate, flower production during the rosette stage, seed with reduced filiform appendages, coriaceous narrow leaves, decurrent leaf attachment, and pyrophytic habit, with the production of a thickened rootstock. A key to this aggregate was proposed in Mey *et al.* (2010).



Fig. 1 *Nepenthes bokorensis*, Mount Bokor (© F. Mey).



Fig. 2 *Nepenthes holdenii*, Cardamom Mountains (© F. Mey).



Fig. 3 *Nepenthes kampotiana* from Trat, Thailand (© M. Catalano).



Fig. 4 *Nepenthes mirabilis*, Kbal Chay (© F. Mey).



Fig. 5 *Nepenthes smilesii*, Kampot area (© F. Mey).



Fig. 6 *Nepenthes smilesii* x *mirabilis*, Kampot area (© F. Mey).



Fig. 7 Unidentified taxon, Cardamom Mountains (© J. Holden).

Key to the *Nepenthes* of Cambodia

- 1a. Leaves petiolate, margins of lower leaves fimbriate..... *N. mirabilis*
- 1b. Leaves sub-petiolate to sessile, slightly to strongly decurrent leaf attachment 2
- 2a. Leaves lanceolate to oblong, inflorescences with scattered 2-flowered partial peduncles, wholly infundibular upper pitchers, vaulted lid, striped bulbous peristome..... *N. bokorensis*
- 2b. Leaves linear to linear-lanceolate, 1-flowered or 2-flowered pedicellate inflorescences.....3
- 3a. Short hairs on all vegetative parts, tendril as long as or shorter than pitcher..... *N. smilesii*
- 3b. Stem and leaves glabrous (pitcher and tendril excluded), tendril longer than pitcher.....4
- 4a. 1-flowered pedicels on both male and female inflorescences, cylindrical peristome.....
..... *N. kampfotiana*
- 4b. 2-flowered partial peduncles on both male and female inflorescences, slightly sinuate peristome..... *N. holdenii*

Systematic accounts

Nepenthes bokorensis Mey (Fig. 1)

Nepenthes bokorensis Mey, in *Carniflora Australis - Journal of the Australasian Carnivorous Plants Society*, 7(1), 6–15 (2009).

N. bokor Cheek in *Kew Bulletin* 64, 319-325 (2009).

Type: Marie Martin 1231 bis (holo P!), southern Cambodia, province of Kampot, Phnom Bokor, 800 m, 07 XII 1968.

Distinguishing characteristics: A member of the *N. thorelii* aggregate. Leaves coriaceous, subpetiolate;

lamina oblongue to lanceolate; long tendril. Upper pitchers wholly infundibular; peristome cylindrical and bulbous, often striped, lid orbicular with a cordate base, vaulted. Inflorescence with flowers borne solitary on pedicels, occasionally on 2-flowered partial peduncles, usually without bracts. Indumentum variable.

Material examined: M. Martin 1231 bis (holo P!), Bokor Hill, 800 m, province of Kampot, Cambodia. Chevalier 36411, 36429, Damrei Mountains (P!). Geoffray 324, 325, 326, 327, 328 (P!), Popokvil Falls, Bokor Hill, 960 m, province of Kampot, Cambodia. Mey 3 (RUPP!), Phnom Bokor (Bokor Hill), 992 m. Middleton & Monyrak 589 (P!), Bokor Hill, 944 m. Poilane 206, 14728 (P!).

Distribution: Endemic to Phnom Bokor (Bokor National Park). This species has been collected from the road leading to the summit plateau and from the Popokvil Falls. Whether or not the species grows elsewhere in the extensive Bokor massif or in the Phnom Damrei (Elephant Mountains) range remains to be answered. Additional surveys are required.

Ecology: Pyrophyte. 800-1,000 metres above sea level. Inhabits clearings in lower montane forest and the edge of forests. Seasonally wet habitats.

Nepenthes holdenii Mey (Fig. 2)

Nepenthes holdenii Mey, in S.R. McPherson (ed.) *Carnivorous Plants and their Habitats: Volume 2*, pp. 1,306-1,331 (2010).

Type: Mey 1A (holo, RUPP!), western Cambodia, Cardamom Mountains, province of Pursat, 653 m, 1 VIII 2009.

Distinguishing characteristics: A member of the *N. thorelii* aggregate. Leaves coriaceous, sub-petiolate; lamina linear to linear lanceolate; long tendril.

[Editor's note: In this paper, the herbaria acronyms are: P = Muséum National d'Histoire Naturelle, Paris, France; and RUPP = Royal University of Phnom Penh, Cambodia. Specimen acronyms are: holo = holotype; synt = syntype; iso = isotype. An exclamation mark (!) indicates that the author has examined that specimen, while an absence of an exclamation mark means the author did not examine the specimen or saw only its photograph].

Upper pitchers infundibular; slightly sinuated peristome. Lid elliptic with a cordate base, not vaulted. Inflorescences male and female with 2-flowered partial peduncles, usually with bracts. Indumentum glabrous except on leaf axils, tendril and pitchers.

Material examined: Mey 1A (holo, RUPP!), Cardamom Mountains, 650 m, province of Pursat, Cambodia, 1 VIII 2009. Mey 1B, 1C, 1D (iso RUPP!), *ibid.* Mey 7A, 7B, 7C (RUPP!), Cardamom Mountains, 760 m, province of Pursat, Cambodia, 12 VIII 2009. Neang & Holden 1, 2, 3, 4, 5, 6 (RUPP photo), Cardamom Mountains, between 600-750 m, province of Pursat, Cambodia, VII 2008.

Distribution: 600-800 m above sea level. Known only from two peaks in the western Cardamom Mountains in Pursat Province. Further study may reveal the presence of this species on other peaks in the extensive Cardamom Mountains range.

Ecology: Pyrophyte. Inhabits the transitional zone between lowland evergreen forest and low montane evergreen forest. *Nepenthes holdenii* grows on steep ridges in peaty soil, in bright to fully sun-exposed areas.

Nepenthes kampoiana Lecomte (Fig. 3)

Nepenthes kampoiana Lecomte, in *Les Nepenthes d'Indo-Chine. Notulae Systematicae*, pp. 62-63 (1909).

N. geoffrayi Lecomte, in *Les Nepenthes d'Indo-Chine. Notulae Systematicae*, p. 62 (1909).

Types: Geoffray 89, 90, 191, 362 (all P!), Cambodia, Kampot.

Distinguishing characteristics: A member of the *N. thorelii* aggregate. Leaves coriaceous, sub-petiolate; lamina linear to lanceolate; long tendril. Lower pitchers ovate in the lower third, narrowing above. Upper pitchers cylindrical with a bulbous base, to obovate. Peristome narrow, usually without stripes. Lid orbicular with a cordate base, not vaulted. Inflorescence with solitary male and female flowers

borne on pedicels. Indumentum absent except on leaf axils, tendril and pitchers.

Material examined: Geoffray 89, 90, 191, 362 (synt P!), Kampot, Cambodia.

Distribution: Kampot Province. *Nepenthes kampoiana* has not been reported in Cambodia since its description in 1909. Unfortunately, Geoffray, the original collector, did not specify the exact location: "Kampot" could mean either the province or its main city. The author of the present paper has tried to search for *N. kampoiana* near Kampot city several times in vain. *Nepenthes kampoiana* has been found in Thailand (Catalano, 2010), in Trat Province near the south western border of Cambodia. Additional investigations are required to locate *N. kampoiana* on the Cambodian side, including the extreme western part of Phnom Samkos Wildlife Sanctuary.

Ecology: Pyrophyte. Inhabits seasonally inundated open savannahs and grasslands.

Nepenthes mirabilis (Loureiro) Druce (Fig. 4)

Nepenthes mirabilis (Loureiro) Druce, in *Report of the Botanical Society and Exchange Club of the British Isles, 1916*, p. 601 (1917).

Phyllamphora mirabilis Loureiro, *De Flora Cochinchinensis*, 2, p. 606 (1790).

Nepenthes phyllamphora Willdenow, *Caroli Linnaei Species Plantarum*, 4, p. 874 (1805).

N. phyllamphora Willdenow var. *pediculata* Lecomte in *Les Nepenthes d'Indo-Chine. Notulae Systematicae*, p. 65 (1909).

Type: Loureiro s. n. Vietnam, near Hue.

Distinguishing characteristics: This taxon does not produce a thickened rootstock. Leaves chartaceous, petiolate; lamina oblong to lanceolate. Lower pitchers bulbous at the base with a distinct hip at the lower third; lid orbicular to ovate. Upper pitchers wholly cylindrical, sometimes with a swollen base. Inflorescence with male and female flowers borne solitary on pedicels, without bracts. Indumentum,

young parts with short hairs; mature plants glabrous; margins of lower leaves fimbriate.

Material examined: Kbal Chay, *vide* Mey 2007, 2009. Kep, *vide* Mey 2009. Sihanoukville, *vide* Mey 2009. Kampot city, *vide* Mey 2009, 2010.

Distribution: This is the most widespread species of this genus. *Nepenthes mirabilis* occurs in the four countries of the Indochinese Peninsula and throughout the Malesian region (Indonesia, Malaysia, Brunei, Singapore, the Philippines, Papua New Guinea and northern Australia). This species was collected in Cambodia in the 19th Century, in small copses near Kep city (Lecomte, 1909). Nowadays, it still grows around Kep (pers. obs.) and it has also been found in two localities near Kampot city: one in wet grassland and another near a paddy field. Given the simple growing conditions demanded by this species, it is likely it grows in many similar habitats along the southern coast of Cambodia. This species has also been found growing in small numbers along roadside ditches around Sihanoukville, and there is an established population in Kbal Chay nearby.

Ecology: Inhabits wet localities along roads or paddy fields.

Nepenthes smilesii Hemsley (Fig. 5)

Nepenthes smilesii Hemsley, in *Kew Bulletin*, p. 116 (1895).

N. anamensis Macfarlane, in *Nepenthaceae*, A. Engler, *Das Pflanzenreich*, pp. 39-40 (1908).

Type: Smiles F.S. (K), northern Siam, Baw Saw, Nam Kawng, 22 V 1893.

Distinguishing characteristics: A member of the *N. thorelii* aggregate. Leaves coriaceous, subpetiolate; lamina narrowly linear to lanceolate, short tendril. Lower pitchers often cylindrical with a swollen base; peristome narrow, usually without stripes. Upper pitchers, cylindrical with a swollen base, to infundibular. Lid usually elliptic with a cordate base, not vaulted. Inflorescence with male and

female flowers borne solitary on pedicels. Indumentum, the whole plant is covered with hairs.

Material examined: Mey 2 (RUPP!), Kirirom National Park, 712 m, province of Kampong Speu, Cambodia. Mey 4 (RUPP!), Kampot city, 16 m, province of Kampot, Cambodia. Poilane 17457 (P!), south of Chambok, province of Kampong Speu, Cambodia. Kampot city, *vide* Mey, 2010.

Distribution: Apart from *N. mirabilis*, this is the most widespread species in the Indochinese Peninsula, known from Cambodia, Laos, Thailand and Vietnam. It has been found at sea level in Kampot and between 600-720 m in Kirirom National Park. The low altitudinal range around Kampot city is unusual because *N. smilesii* is usually found between 500 and 1,000 m in the other countries of Indochina.

Ecology: Pyrophyte. Usually found in seasonally wet habitats such as open sandy savannahs and grasslands. In Kirirom National Park, *Nepenthes smilesii* grows in clearings among pine trees.

Nepenthes smilesii x *mirabilis* (Fig. 6)

Type: None. This natural hybrid has not been formally described as a taxon.

Distinguishing characteristics: The following short description is based on a single specimen. Leaves chartaceous, sub-petiolate; lamina lanceolate. Lower pitchers wholly cylindrical with a distinct hip at the lower third; lid orbicular. Upper pitchers completely green, infundibular; peristome cylindrical and bulbous, without stripes. Inflorescence unknown. Indumentum, plants lined with short hairs. The presence of hairs on the whole plant discards the possibility of the glabrous *N. kampfotiana*, which has been collected in the same area, to be one of the parents.

Material examined: Mey 6 (RUPP!), near Kampot city, 14 m, Kampot Province, Cambodia.

Distribution: A single large specimen, with multiple offshoots, of this natural hybrid has been recorded

from Kampot city (exact locality withheld for conservation purposes).

Ecology: *Nepenthes smilesii x mirabilis* has been found in a large, open, inundated area, close to a stream, with populations of *Utricularia caerulea* and *Drosera indica*. Populations of the pyrophytic *N. smilesii* and *N. mirabilis* were found within a few kilometres of the site. It is not known whether this hybrid produces a tuberous stem or a thickened root system like the species of the *N. thorelii* aggregate.

Other taxa that may occur in Cambodia

Populations of unknown *Nepenthes* have been observed in Botum Sakor National Park, Koh Rong, and several parts of the Cardamom Mountains (J. Holden and V. Ly, pers. comm.). For the moment, they are known to the author of the present paper only from photographs (e.g. Fig. 7).

Of the other Indochinese pitcher plants, *Nepenthes thorelii* Lecomte is a Vietnamese species that has been collected near the Cambodian border in the former Vietnamese province of Song Bé (now Binh Duong and Binh Phuoc Provinces). This species has not been officially recorded since its description in 1909 and is therefore believed to be on the brink of extinction in Vietnam (Mey, 2010). It is conceivable that it also occurs on the other side of the border in Cambodia, and a survey of this area is required.

Nepenthes chang M. Catal., a close Thai relative of *N. holdenii* which grows in Khao Kuap in the Banthad Mountains, could also be found in the neighbouring Cardamom Mountains of Cambodia.

Ethnobotany and conservation

Pitcher plants have long been used in Cambodia for traditional medicine. *Nepenthes mirabilis* is used in the countryside around Kampot city to make medicines (pers. obs.). Villagers who live near the type locality of *Nepenthes holdenii* report using the leaves and roots of this plant to make a decoction

to cure fever and pain (pers. comm.). People from Kampot used to boil the roots of *N. bokorensis* and give them to pregnant women to ease their pains (Marie Martin, herbarium label on Marie Martin 1231 bis).

As is the case in most parts of the world, *Nepenthes* are greatly threatened by human activities. Cambodia's biodiversity is under pressure from various threats such as logging, poaching, land speculation and encroachment in protected areas and other forests, invasive alien species, and transformation of natural habitats by roads, agricultural concessions, mines and hydroelectric dams (Daltry, 2008). The lowland *Nepenthes* species especially have been wiped out from most of the fields, grasslands and wastelands where they used to grow. According to Cambodian people the author met on various expeditions, pitcher plants were once much more common, especially before the Khmer Rouge regime. The Cambodian lowland species (*N. kam-potiana*, *N. mirabilis*, *N. smilesii*) are the most accessible and hence the most vulnerable. Any remnant specimens that survive development are also likely to be collected for traditional uses.

All *Nepenthes* species are on Appendix II of CITES (www.cites.org), but this regulates only their international trade. It is important to locate, study and name *Nepenthes* populations in Cambodia to assign them with their correct category of threat on the IUCN Red List (see IUCN, 2001), ensure they are adequately protected under national law, and guide and develop in situ or ex-situ conservation programmes. The following paragraphs summarise the threats that face each of the currently known Cambodian pitcher plants.

Nepenthes bokorensis: This species, endemic to a ridge of Phnom Bokor and the Popokvil Falls, is at risk because its habitat has been leased for private development. Monitoring is needed and further explorations of the plateau, the National Park and the Phnom Damrei range are required to locate any additional populations of this species. *Nepenthes bokorensis* has been assessed as Vulnerable accord-

ing to IUCN criteria by Mey (2009), while Cheek & Jebb (2009) assessed it as Endangered B2ab(iii).

Nepenthes holdenii: This recently described species is known only from a couple of peaks of the Cardamom Mountains. It has been assessed as Near Threatened (Mey *et al.*, 2010). The known populations are scattered, highly localised and composed of only a few dozen specimens. In the short term, the main threat is likely to come from over-collection. In the long term, the species could be affected by habitat loss, logging and land speculation.

Nepenthes kampotiana: This species has not been reported since it was first described by Lecomte in 1909. This taxon was collected somewhere in Kampot Province in the late 19th Century and must now be very rare or even extinct. Attempts to rediscover it in the Kampot area were unsuccessful. Isolated populations, believed to belong to this species, were observed by Catalano (2010) in the Thai province of Trat, near the south-western Cambodian border. It is important to locate this species, named after a Cambodian locality, to develop an appropriate conservation programme.

Nepenthes mirabilis: This is the least threatened of the Cambodian species. It is known from several localities in the southern coast and it is possible many other small populations will be found in the future. The Kbal Chay roadside populations consist of several dozen individuals, which could be easily wiped out by development. The other known populations consist of small numbers of specimens persisting on wastelands or paddy fields. *Nepenthes mirabilis* seems to have a patchy distribution in southern Cambodia and was once fairly common. It may still grow in good numbers in protected areas, such as Botum Sakor National Park. It is also known from the Vietnamese island of Phu Quoc, south of Kampot city. This taxon may be classified as Least Concern.

Nepenthes smilesii: Cambodian populations of this widespread Indochinese species (also known from Thailand, Laos and Vietnam) have been studied on the Kirirom plateau at intermediate altitudes (600-700 m above sea level), and around

Kampot city, close to sea level. The population on the Kirirom plateau seems to be well established in an eco-tourism site where there appears to be no immediate threat. The lowland populations are highly endangered. Only two isolated populations around Kampot city have been documented, each of which consists of a small number of plants near crop plantations and paddy fields. However, there are insufficient data to assess the status of this species, and it probably ought to be classed as Data Deficient (IUCN, 2001).

Nepenthes smilesii x mirabilis: During numerous expeditions in Cambodia, only one plant of this natural hybrid has been documented. This is a very old, large specimen that grows in isolation near Kampot city. Further research might reveal more such hybrids, but given the increasing rarity of *Nepenthes*, the loss of their habitats in the Cambodian lowlands, and the natural rarity of *Nepenthes* hybrids, their number is likely to be very low.

Conclusions

Studies of the genus *Nepenthes* in Cambodia have only recently begun, with surveys having covered only a very small part of this territory. Many areas in Cambodia that have suitable *Nepenthes* habitat have yet to be prospected. The Cardamom Mountains range, parts of the Damrei (Elephant) Mountains, the islands of the southern coast and the numerous southern provinces along the Vietnam border, are especially likely to reveal more *Nepenthes* populations.

Moreover, several populations of unidentified pitcher plants have been observed. Additional botanical survey work is certainly warranted and is likely to result in new discoveries that will help to reveal the extent of the diversity of *Nepenthes* in Cambodia.

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