Conservation status of some commercialized succulent species of Madagascar

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Abstract

Succulent plants characterize the vegetation of the southern and southwestern portions of Madagascar. The region presents the highest endemicity on the island; numerous species are only known from one or two locations and are classified as threatened. Extensive fieldwork was undertaken of 12 commercialized succulent species, to determine aspects of their ecology, habitat preferences, abundance, and risk of extinction. This paper presents the first data or updates on the conservation status of these taxa. The criteria for conservation assessments based on the International Union for Conservation of Nature (IUCN) Red List categories allowed us to determine that two species are critically endangered (CR): *Cyphostemma montagnacii* Desc. (Vitaceae) and *Operculicarya pachypus* Perrier (Anacardiaceae); five are endangered (EN): *Adenia subsessifolia* Perrier (Passifloraceae), *O. hyphaenoides* Perrier*, Senna meridionalis* (Viguier) du Puy (Fabaceae)*, Zygosicyos pubescens* Humbert and *Z. tripartitus* Humbert (Cucurbitaceae); and five species are classified vulnerable (VU): *Adenia firingalavensis* (Drake) Harms*, A. olaboensis* Claverie, *C. elephantopus* Desc.*, C. laza* Desc., and *O. decaryi* Perrier.

Key words: *Adenia*, *Cyphostemma*, *Operculicarya*, *Senna*, *Zygosicyos*, conservation status, Madagascar

Résumé détaillé

Les forêts du Sud et du Sud-ouest malgaches sont caractérisées par la présence de plantes succulentes facilement reconnaissables par leurs caractères décidus et xérophytiques. Le microendémisme floristique représente un des aspects qui caractérise les formations végétales de cette partie de l'île.

Les 12 espèces étudiées sont très recherchées pour leur forme attractive et font l'objet de commerce international. Sept d'entre elles ont été récemment intégrées dans l'Annexe II de la CITES : *Adenia olaboensis* Claverie (Passifloraceae), *Cyphostemma elephantopus* Desc. et *C. montagnacii* Desc. (Vitaceae), *Operculicarya hyphaenoides* Perrier, *O. pachypus* Perrier (Anacardiaceae), *Zygosicyos pubescens* Humbert et *Z. tripartitus* Humbert (Cucurbitaceae).

Malgré l'importance économique pour l'horticulture internationale des plantes succulentes, la plupart d'entre elles n'ont pas fait l'objet de révision taxonomique depuis leur description sauf pour le genre *Operculicarya* spp. En tant que plantes ornementales, *Operculicarya* est aussi utilisé en médicine traditionnelle et comme bois de chauffe à Andatabo.

Les investigations biologique et écologique réalisées au cours de cette étude dans les diverses zones de collecte ont permis d'avoir un aperçu global sur l'abondance, l'habitat, les menaces et pressions qui pèsent sur les espèces succulentes. A partir des observations sur le terrain, les sous populations sont relativement rares, les habitats de la plupart des espèces sont perturbés par des activités anthropiques telles que les feux et le défrichement entraînant la régression progressive de la forêt. La distribution de chaque espèce expliquée par les zones d'occurrence et les zones d'occupation sont calculées à partir d'analyses bibliographiques et de consultations des herbiers collectés. Certaines espèces telles que : *O. decaryi, C. laza* et *A. olaboensis* ont une large distribution mais très fragmentée. D'autres espèces notamment *Senna meridionalis, C. elephantopus, C. montagnacii, Z. pubescens* et *Z. tripartitus,* sont très spécifiques à une ou deux localités.

En tenant compte des critères d'évaluation des menaces selon la Liste Rouge de l'UICN, deux espèces sont classées en Danger Critique d'extinction (CR) : *C. montagnacii* et *O. pachypus,* cinq sont en Danger (EN) : *A. subsessifolia*, *O. hyphaenoides, S. meridionalis, Z. pubescens* et *Z. tripartitus*, et enfin cinq espèces sont classées Vulnérables (VU) : *A. firingalavensis, A. olaboensis*, *C. elephantopus, C. laza* et *O. decaryi*.

Ravaomanalina, B. H., Rakotonavalona, A. & Rakouth, B. 2011. Conservation status of some commercialized succulent species of Madagascar. *Malagasy Nature*, 5: 59-67.

Sur le plan national, les données biologique et écologique des espèces étudiées ainsi obtenues pourraient servir de base dans l'établissement d'un plan de gestion locale de l'espèce et de la conservation *ex situ*.

Sur le plan international, les informations sur les effectifs de la population, l'aire de répartition et de distribution, les tendances de la population face aux pressions et menaces, permettront aux Autorités Scientifiques de la Convention Internationale sur le trafic des espèces Menacées (CITES), de donner des avis scientifiques non préjudiciables à la survie des espèces (voir Rosser & Haywood, 2002).

Mots clés : *Adenia*, *Cyphostemma*, *Operculicarya*, *Senna*, *Zygosicyos*, statut de conservation, Madagascar

Introduction

The south and southwest of Madagascar are home to many succulent plant species. The local xerophytic vegetation is dominated by Didiereaceae-*Euphorbia* species (Moat & Smith, 2007), but also a great variety of other plants. Approximately, 90% of the vascular plants occurring in this region are endemic (Philippson, 1996). Many of these species are rare and classified in the IUCN Red List as threatened because they are only found in a specific microhabitat and their populations are notably affected by the rapid destruction of the regional native vegetation. The diversity of succulent species, combined with their attractive form, make them extremely popular and highly valued by plant growers around the world as bonsai trees (*Senna meridionalis* and *Operculicarya* spp.). International trade of Malagasy succulent plants has become a serious threat because several endemic plants are subjected to high demand from local and international markets. Further, despite the extraordinary local diversity and specificity of succulent species in the south of Madagascar, some species are insufficiently or not at all represented within the current protected areas network.

While several studies provide important information on the identification and description of Malagasy succulent species, to our knowledge, little attention has been given to treating eco-geographic features of some commercialized succulent species, as well as their abundance, frequency, and revised conservation status using the IUCN (2001) Red List criteria. In the context of this study, we conducted inventories of existing populations of certain succulent plant species to assess their conservation status and the impact of selective exploitation on their future survival.

Materials and Methods

Twelve endemic species were selected for this study associated with their high international trade demand. These are *Adenia firingalavensis* (Drake) Harms, *A*. *olaboensis* Claverie, and *A*. *subsessifolia* Perrier (Passifloraceae); *Senna meridionalis* (Viguier) du Puy (Fabaceae); *Cyphostemma elephantopus* Desc., *C*. *laza* Desc., and *C*. *montagnacii* Desc. (Vitaceae); *Operculicarya decaryi* Perrier, *O*. *hyphaenoides* Perrier, and *O*. *pachypus* Perrier (Anacardiaceae); and *Zygosicyos pubescens* Humbert and *Z*. *tripartitus* Humbert (Cucurbitaceae) (Figures 1-3). Different characteristics of these species are presented in Table 1.

Table 1. List and brief description of the 12 species studied.

Scientific name	Family name	Vernacular name(s)	Description	CITES status
Adenia firingalavensis	Passifloraceae	*lokoranga, trangahy, olabory, holabe , holaboay, kajabaka, lazamaintso*	Green swollen stem base, covered with tuberculate conical processes.	-
Adenia olaboensis	Passifloraceae	*vahisasety, vahimboay, olaboay, holabe, hola, rehola*	Dark-green, swollen stem base, covered with tuberculate conical processes.	II
Adenia subsessifolia	Passifloraceae	*katakata*	Stem succulent and caudiciform plant, with subsessile leaves.	-
Cyphostemma elephantopus	Vitaceae	*lazampasika*	Caudiciform (Descoings, 1962).	II
Cyphostemma laza	Vitaceae	*laza, lazambohitra*	Plant with large trunk but smaller than *C. elephantopus* (Descoings, 1962).	-
Cyphostemma montagnacii	Vitaceae	*lazampasika*	Plant with large trunks (Descoings, 1962).	II

Table 1. (cont.)

Scientific name	Family name	Vernacular name(s)	Description	CITES status
Operculicarya decaryi	Anacardiaceae	*jabihy, tabihy, zabia daro, zaby*	Small-branched tree with bole like or conical trunk, paripinnate deciduous leaves.	-
Operculicarya hyphaenoides	Anacardiaceae	*jabihy, sakoakomba, saby, tabily, zabily*	Well-branched shrub or small tree about 1.5 m, deciduous.	II
Operculicarya pachypus	Anacardiaceae	*tabily, beoditra, botiboty, jabihy, zaby*	Very short branched shrub with tiny compound leaves and distinctive zig-zag branches.	II
Senna meridionalis	Fabaceae	*taraby, andapary, tainjazamena*	A deciduous, much branched shrub, twigs smooth, thick and rigid, tortuous and zigzag.	-
Zygosicyos pubescens	Cucurbitaceae	*tobory*	Dioecious plant forms a large tuberous caudex.	II
Zygosicyos tripartitus	Cucurbitaceae	*betoboky*	Dioecious plant, perennial caudiciform.	II

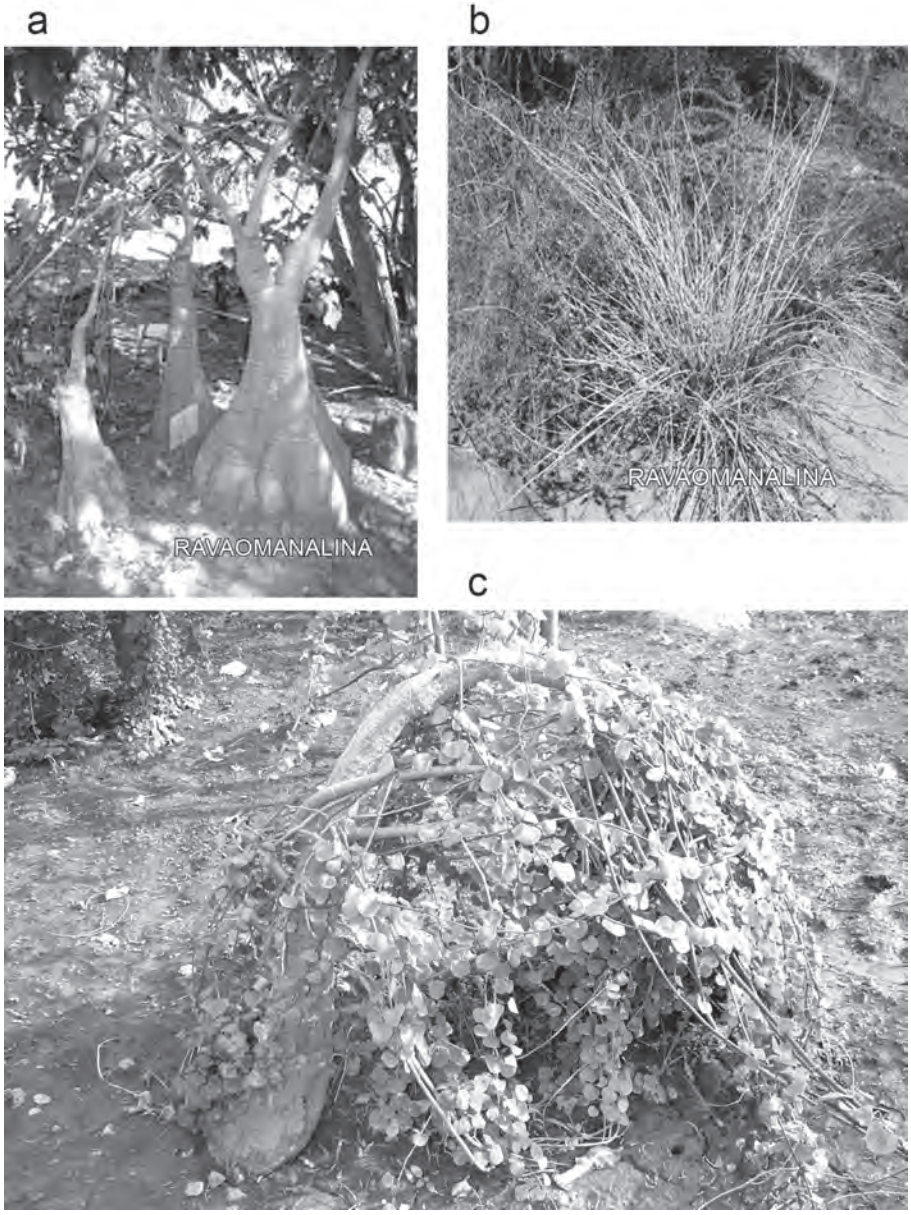

Figure 1. Succulent plants of Madagascar: a) *Adenia firingalavensis*, b) *A. subsessifolia*, and c) *A. olaboensis*.

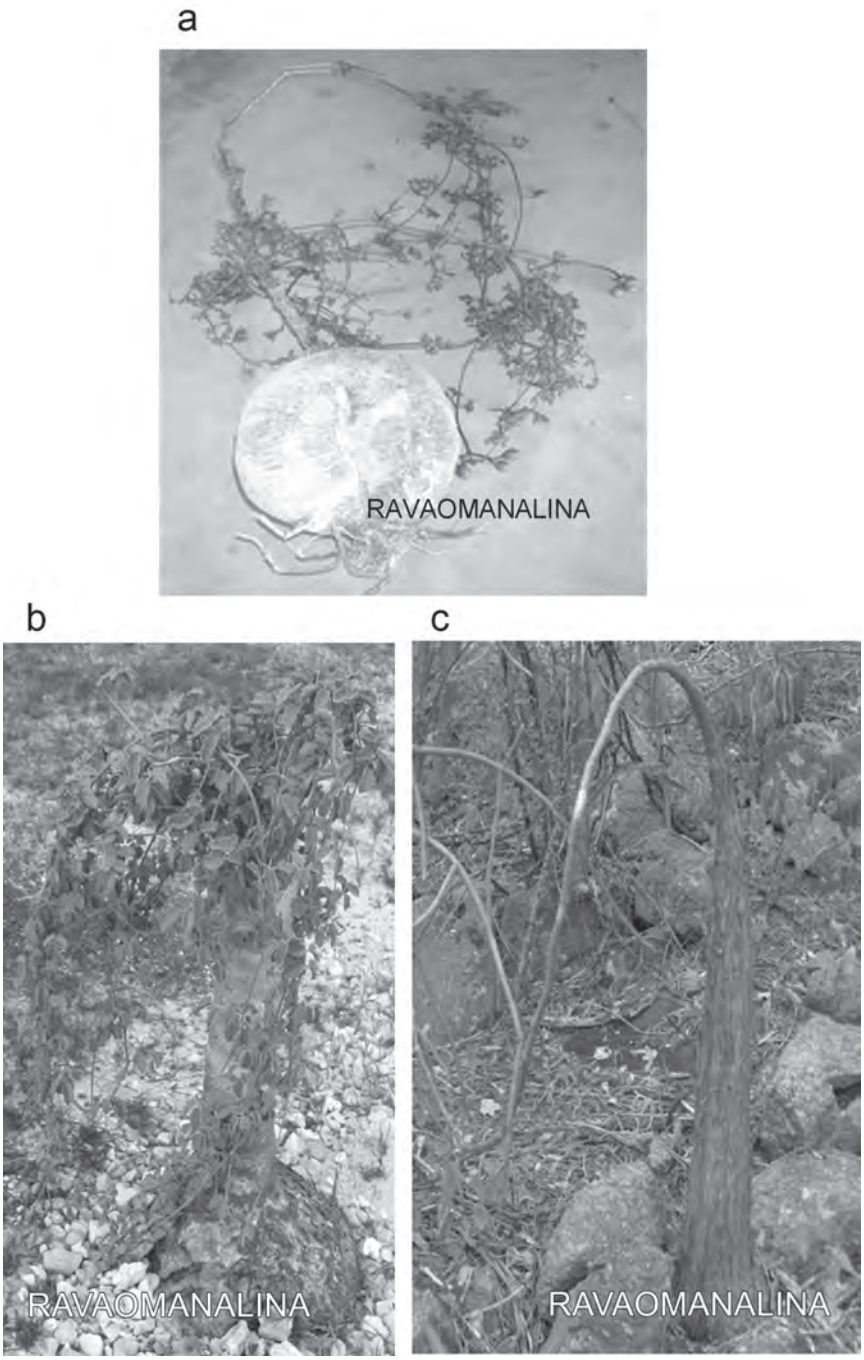

Figure 2. Succulent plants of Madagascar: a) *Cyphostemma montagnacii*, b) *C. elephantopus*, and c) *C. laza*.

Study sites

Preliminary reconnaissance visits preceded the ecological study in order to identify sites where it was possible to locate the study species and to evaluate their relative abundance. Potential sites were chosen based on data in the literature and herbarium specimens. The final study sites were selected according to their (a) richness in succulents, (b) accessibility, and (c) high collection pressures.

Inventories were conducted around the villages of Andoharano, Andatabo, Ankilibe, Tsingoritelo, Antsokay, Esomony, Tranomaro, Ankodida, Andrahomana, Ihotry Tongobory, Ampanihy, Antrehaka, Tsihombe, Cap Sainte Marie, Behara, and Saint-Augustin (near sea-level to 100 m). The natural forest formations of these areas are dominated by “South western dry spiny forest-thicket” (Moat & Smith, 2007), but several of the sites had characteristics approaching “western dry [deciduous] forest” as defined by Moat & Smith (2007). Average annual rainfall of the region is less than 700 mm with the annual mean temperature of 15°C and annual mean maximum temperature 30°C (Donque, 1975).

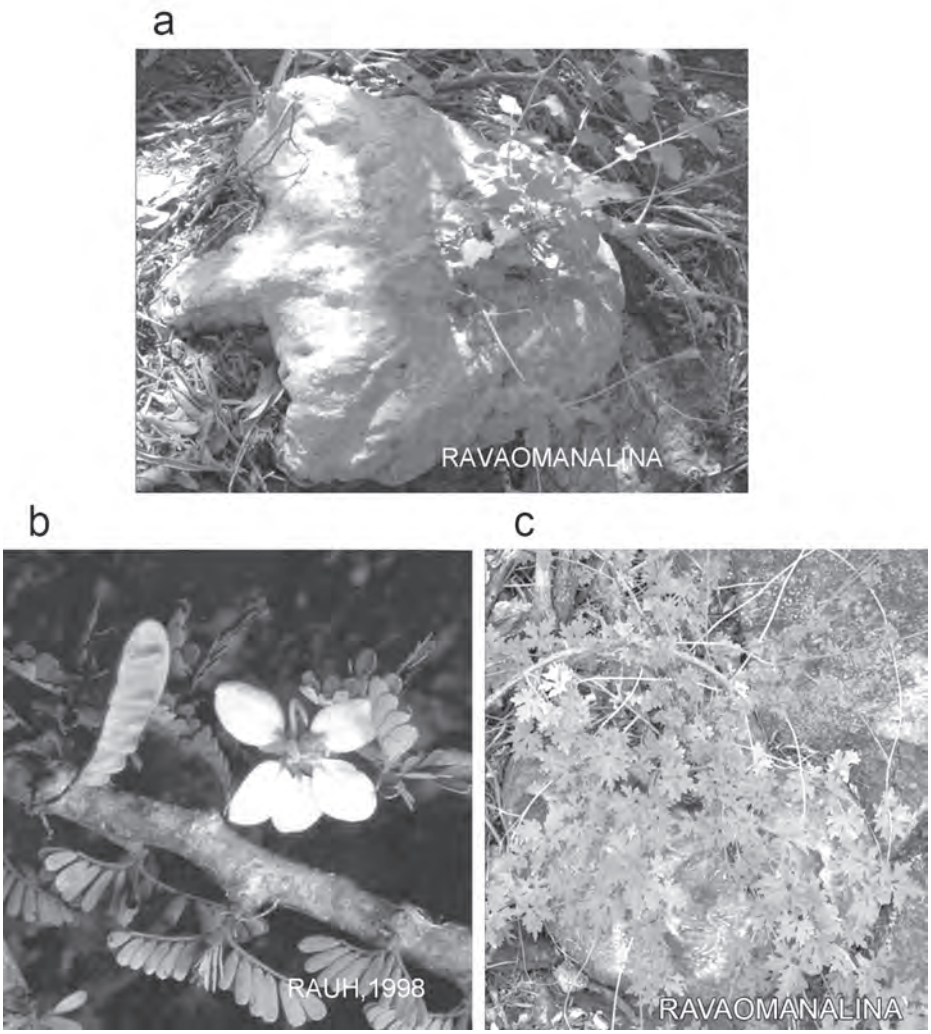

Figure 3. Succulent plants of Madagascar: a) *Zygosicyos pubescens*, b) *Senna meridionalis*, and c) *Z. tripartitus*.

Ethnobotanical interviews

Ethnobotanical interviews were conducted with local plant collectors using a series of open questions concerning the use of the target succulent plants, the quantity exploited (number and size), the period and mode of collection, the level of trade and prices, the legality of collection permits, and the impact of the exploitation on their surrounding populations and vegetational communities.

Ecological study

Ten plots, each 10 x 10 m, were laid out in areas of maximum abundance of the target species. A general description of the vegetation was recorded as well as the soil type, the associated flora, and the physiographic features. All adult individuals of the target species were recorded, in order to assess their frequency. Adult individuals were considered fertile. Plots were installed according to Duvigneaud's (1980) abundance method.

Specific abundance

Specific abundance is defined as the number of individuals of a species in the area of known occupation (Schatz, 2000). We estimated the occupation area of a subpopulation at a given site. Specific abundance was calculated according to the formula of Godron *et al*. (1983):

$$A = S \times d$$

where, A: specific abundance, S: subpopulation occupation area, d: average density, which was calculated by computing the number of mature individuals within a plot.

A sampling plot of 10 x 10 m was installed in order to count the number of mature individuals. Each plot was subdivided into five subplots of 2 x 2 m, which were taken randomly to assess the species density.

Natural regeneration

In order to assess natural regeneration, a seedling plot of 50 x 20 m was also installed at each site. All seedlings and young plants of the targeted species were counted. The rate of regeneration was calculated using Rothe's formula (1964):

$$TR\ (\%) = n / N \times 100$$

where, TR: rate of regeneration, n: number of seedlings, and N: number of adults

According to the Rothe scale:

- If TR < 100%, regeneration of a species is in a precarious situation,
- If 100 < TR < 1000%, the regeneration is good,
- If TR > 1000%, the regeneration is very good.

Conservation status

GPS coordinates for each target species encountered in the wild were recorded in addition to data obtained from herbarium specimens. Arc view software was used to assess the "area of occurrence" and the "area of occupancy" for each species. We used the categories of IUCN (2001) to define the conservation status of our study species.

Results

Ethnobotanical results

All the 12 studied species are exploited as ornamental plants. Local villagers collect the plants in the wild and sell them to local collectors or the intermediate traders. The plants are then transported and stored or replanted at the operator's nursery before being commercialized on the local market or exported abroad. According to the local collectors, the villagers are not aware of the importance of those ornamental plants and sell them at very low cost to subsidize their daily needs. In addition to their ornamental utilization, the three *Operculicarya* spp. are also used as medicinal plants and for making charcoal in Andatabo.

Specific abundance and regeneration

Specific abundance and regeneration rates of the studied species are given in Table 2. Abundances varied significantly between the studied species. *Operculicarya pachypus* was the most abundant with 950 ind/ha, which is almost certainly associated with the ability of this species to sprout after cutting. *Operculicarya decaryi* was also abundant and

Table 2. Specific abundance, regeneration rate, distribution analysis, and conservation status of the 12 species studied. SA: specific abundance, SN: subpopulation number, TR: regeneration rate, EOO: area of occurrence, AOO: area of occupancy.

Species	Site(s)	Area (ha)	Density (ind/ha)	SA (ind)	SN	TR (%)	EOO (km²)	AOO (km²)	Conservation status
Adenia firingalavensis	Andoharano	10	150	1 500	6	108	2 500	520	VU B2b (i,ii,iii) C2(b)
Adenia olaboensis	Tongobory	10	250	2 500	10	86	15 000	1 867	VU B2b (i, ii, iii).
	Andatabo	2	100	200					
Adenia subsessilifolia	Behara	3	25	75	3	122	90	8	EN B2abc (ii, iii)
	Cape Ste Marie	5	28	140					
Cyphostemma elephantopus	Ankilibe	5	20	100	2	19	835	19	VU B2b (i, ii, iii)
	Antsokay	2	27	54					
Cyphostemma laza	Tranomaro	5	728	3 640	10	4	34 805	5 288	VU B2b (i, ii, iii)
Cyphostemma montagnacii	Andatabo	2	25	50	1	117	262	96	CR B1 ab (ii, iii + 2ab (ii, iii)
	Tongobory	6	266	1 596					
Operculicarya decaryi	Ampanihy	2	220	440	10	121	49 541	8 409	VU B2b (i, ii, iii)
	Behara	8	100	800					
Operculicarya hyphaenoides	Saint Augustin	5	266	1 330	2	104	788	463	EN B2abc (ii, iii)
	Andatabo	6	189	1 134					
Operculicarya pachypus	Andatabo	6	940	5 640	1	81	378	103	CR B1 ab (ii, iii + 2ab (ii, iii)
Senna meridionalis	Ahaviro	5	420	2 100	3	111	101	10	EN B1ab (ii,iii) + 2ab (ii,iii)
Zygosicyos pubescens	Ekodida	10	150	1 500	1	488	18	9	EN B2abc (ii, iii)
Zygosicyos tripartitus	Tranomaro	10	250	2 500	1	144	9	9	EN B2abc (ii, iii)

widespread. The abundance of *Cyphostemma elephantopus* was low with 100 ind/ha; this is associated with its habitat at Ankilibe Andatabo being converted to sites of human habitation. The population of *C*. *laza* in the deciduous forest was found to be dominated by adults, but with few seedlings and apparently problems of recruitment into breeding populations.

The regeneration potential of a plant species indicates its capacity to reproduce. The maximum regeneration rate recorded was 488% for *Zygosicyos pubescens* and the majority of the other studied species have a relatively good natural regeneration in the range of 100%. The exceptions are *C*. *laza*, *C*. *elephantopus*, and *Adenia olaboensis* that had regeneration rates of 4%, 19%, and 86%, respectively, and this is associated with considerable habitat degradation around the study sites these species were found.

Threats and uses

The main threats to the dry forests of Madagascar are slash-and-burn agriculture, which destroys the forest and increases the area occupied by anthropogenic grassland. Further, annual bush fires and overgrazing by cattle, which reduce the possibility of regeneration, are also major pressures on the remaining natural forests. In addition, there are important discrepancies between the number of specimens collected per species and the maximum number allowed on the government issued collection permits; collectors have the tendency to gather more plants in order to compensate for damaged specimens. Local control by government officials associated with permit regulation is not sufficient and most collectors do not respect the allocated quotas.

Selected harvesting and over exploitation are probably major threats to *Zygosicyos pubescens*, which was only found at one locality in the deciduous forest of Ekodida. Moreover, disturbances caused by human activities, such as bush fires, have greatly reduced its habitat.

La Table area, south of Toliara, is a good example of a seriously perturbed locality. It constitutes a habitat for most of the studied species (*Adenia subsessifolia*, *Cyphostemma montagnacii*, *C*. *elephantopus*, *Senna meridionalis*, *Operculicarya pachypus*, and *O*. *hyphaenoides*). This area suffers from widespread anthropogenic disturbance, such as woodcutting for charcoal production. The surface area of natural vegetation has decreased considerably and, where it survives, increasingly degraded. These changes are due to the absence of an adequate local conservation policy.

Operculicarya decaryi, *C*. *laza*, and *A*. *olaboensis* are widespread but sensitive to harvesting and other threats. *Adenia firingalavensis* and *Z*. *tripartitus* grow in gallery forest on sandstones. This type of forest is being rapidly cut and is one of the most endangered vegetation types in southern Madagascar.

Distribution and conservation status

Distribution

The distributional pattern of a given species provides some indication of its sensitivity to harvesting. Most of the studied species such as *Operculicarya decaryi*, *Cyphostemma laza*, and *Adenia olaboensis*, are widespread but have fragmented distributions. Locally endemic species adapted to specific habitats that are naturally fragmented are likely to be at greater risk from anthropogenic habitat change and the impacts of harvesting. These locally endemic species have restricted distributions varying from 90 to 835 km². They are all endemic to the southern portion of Madagascar and some, such as *Senna meridionalis*, *C*. *elephantopus*, and *C*. *montagnacii*, are microendemics limited to areas such as the Mahafaly Plateau limestone. Two species have very small distributions: *Z. pubescens* (EOO = 18 km², area of occupancy AOO = 9 km²), *Z*. *tripartitus* (EOO = 9 km², AOO = 9 km²). They are found in the forest of Ekodida and Tranomaro. A reduction in the distribution, based on older herbarium records and literature data, was observed for all species.

Conservation status for the studied plant species

- *Operculicarya decaryi* has an EOO of 49 541 km², an AOO of 8 409 km², and 10 subpopulations, two of which are included in protected areas (Andohahela, Beza Mahafaly). It is thus assigned the conservation status of Vulnerable VU B2b (i, ii, iii).
- With an EOO and an AOO of no more than 100 km² and no protected subpopulations, *Adenia subsessifolia*, *O*. *hyphaenoides*, *Zygosicyos pubescens*, and *Z*. *tripartitus* are assigned the conservation status of Endangered EN B2abc (ii, iii). The level of commercial exploitation of the latter species rapidly reduces the existing populations.
- *Cyphostemma laza* has an EOO of 34 805 km² with an AOO of 5 288 km², and 10 subpopulations, five of which are encompassed within protected

areas (Bemaraha, Kirindy [CEPF], Kirindy Mitea, Beza Mahafaly, Andohahela). However, because of notably high harvest pressure, it is assigned the conservation status of Vulnerable VU B2b (i, ii, iii).

- With an EOO well below 500 km², an AOO of 200 km², and no protected subpopulations, *O*. *pachypus* and *C*. *montagnacii* are assigned the conservation status of Critically Endangered CR B1 ab (ii, iii + 2ab (ii, iii).
- With an EOO of less than 100 km², an AOO of 10 km², and only three subpopulations, not one of which is currently included in a protected area, *Senna meridionalis* is assigned a status of Endangered EN B1ab (ii, iii) + 2ab (ii, iii).
- *Adenia olaboensis* has an EOO of 15 000 km², an AOO of 1 867 km², and two subpopulations, all of which are found in protected areas (Andohahela, Beza Mahafaly). It is assigned the conservation status of Vulnerable VU B2b (i, ii, iii).
- With an EOO of less than 5000 km², an AOO of 20 km², no protected subpopulation, and the different threats facing this species, *C*. *elephantopus* is assigned a status of VU B2b (i, ii, iii) (Table 3).

Discussion and recommendations

During this study, the fieldwork was conducted during a relatively short period. In addition, the difficult logistics to reach certain areas limited observations and assessment in some regions and these aspects were taken into account. Therefore, the estimates of area (EOO and AOO) should not be considered definitive. Only seven of the 12 species studied are listed in Appendix II of CITES (Table 1). Information on the IUCN Conservation status of the species will be very important data and required for the proposition of these succulent plants to be listed as CITES taxa.

The xerophytic bush of the southern and the southwestern part of the island, with certain zones having deciduous forest characteristics, have more succulent species than the central-western and northwestern regions and the highest level of local endemism (Rauh, 1998). However, dry deciduous forest and spiny bush vegetation are under very high pressure due to human activities. In spite of the economic importance of the succulent species considered in this study and their great interest for horticulturists, they have not been the subjects of recent taxonomic revisions, with the exception of *Operculicarya* (Randrianasolo & Lowry, 2006).

Between 1995 and 2007, a large number of Malagasy plant species become threatened with extinction as a direct result of habitat destruction and the associated reduction in their distribution and abundance. Conservation of succulents has been recognized as one of the urgent actions to be undertaken because of their ecological significance, including degree of endemism, adaptations, and relative importance as environmental components (ANGAP, 1997).

The number of specimens collected in the wild for trade of these species will have to be well managed and monitored, if not, this will dramatically increase the risk of extinction of these charismatic plants. A system of national collection quotas is necessary in order to ensure regulation of trade, which can be extended and applied to other species. Further, expansion of programs organized by the plant exporting companies of raising plants in captivity for exportation and meeting the set quotas. In fact, the operators are contractually obligated to advance such programs, but this aspect is rarely enforced.

Conclusion

This paper provides the current status of 12 Malagasy plants exploited for local and international trades. According to the IUCN Red List criteria, two species are classified as Critically Endangered (CR): *Cyphostemma montagnacii* and *Operculicarya pachypus*, five species are Endangered (EN): *Adenia subsessifolia*, *O*. *hyphaenoides*, *Senna meridionalis*, *Zygosicyos pubescens*, and *Z*. *tripartitus,* and five species are Vulnerable (VU): *A*. *firingalavensis*, *A*. *olaboensis*, *C*. *laza*, and *O. decaryi*.

The updates proposed here should assist the national scientific CITES authorities (voir Rosser & Haywood, 2002) in setting quotas for the commercial exploitation of these plants. These new data will be useful for developing *ex situ* conservation measures for these species and expanding *ex situ* conservation in protected areas. Exporting companies should be encouraged to become more professional and increase artificial propagation of plants important for international trade.

Acknowledgements

This work was supported by grants from Conservation International, Madagascar. We are grateful to the different individuals who provided material and technical assistance. We would like to thank the collectors who provided unpublished locality

information, as well as to Steve Goodman and an anonymous reviewer for their helpful comments on an earlier version of the manuscript.

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