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Threatened and Rare Ornamental Plants

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Abstract
The application of IUCN criteria and Red List Categories was done for ornamental plants. Main sources of the study were Glen's book, Cultivated Plants of Southern Africa (GLEN, 2002) and the Red List of Threatened Plants, IUCN (2001). About 500 threatened ornamental plants could be found and presented in respective lists. Rare ornamental plants with 209 species is the largest group followed by Vulnerable (147), Endangered (92), Indeterminate (37), Extinct (6) and finally Extinct/Endangered groups with 2 species. A weak positive correlation ($r = +0.36$) was found between the number of threatened species and the number of threatened ornamental species within the families.

Keywords: ornamental plants, IUCN criteria, red list

1 Introduction

Whereas red lists of threatened plants are being highly developed for wild plants and even replaced by green lists (IMBODEN, 1989) and blue lists (GIGON *et al.*, 2000), ornamental plants still lack similar lists. A statistical summary of threatened crop plant species was published by HAMMER (1999) showing that roughly 1000 species of cultivated plants (excluding ornamentals) are threatened (see also LUCAS and SYNGE (1996). An attempt was recently made towards a red list for crop plant species, which presents about 200 threatened cultivated (excluding ornamentals) plants in the IUCN categories (HAMMER and KHOSHBAKHT, 2005b). Now an effort is made to include ornamentals.

IUCN has defined six categories for threatened plants – Extinct, Extinct/Endangered, Endangered, Vulnerable, Rare and Indeterminate (see IUCN (2001) for definitions).

2 Materials and Methods

To obtain a list of threatened ornamental plants at the species level, the book of GLEN (2002) was compared with the Red List of Threatened Plants, IUCN (2001). GLEN (2002) contains about 9.000 species. Most of them are ornamental plants. They are based on observations of about 37.000 specimens of cultivated plants in Southern Africa.

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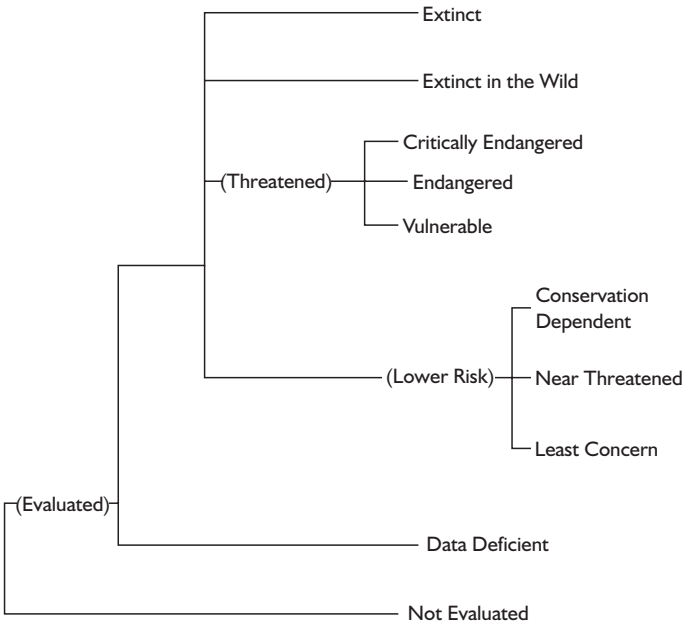
The aim of the list is a Prodromus of a Southern Africa garden flora similar to that of WALTERS *et al.* (1986-2000, 6 volumes) for Europe.
Species available in GLEN (2002) matching with the Red List of Threatened Plants (IUCN, 2001) were arranged alphabetically in tables, according to the following IUCN (2001) categories, see also Fig 1.

Figure 1: Structure of IUCN Red List Categories (from Species Survival Commission; IUCN 1994)



(1) Extinct (Ex): Taxa that are no longer known to exist in the wild after repeated searches of the type localities and other known or likely places.

(2) Extinct/Endangered (Ex/E): Taxa possibly considered to be extinct in the wild.

(3) Endangered (E): Taxa in danger of extinction and whose survival is unlikely if the causal factors continue operating. Included are taxa whose numbers have been reduced to a critical level or whose habitats have been so drastically reduced that they are deemed to be in immediate danger of extinction.

(4) Vulnerable (V): Taxa believed likely to move into the Endangered category in the near future if the causal factors continue operating. Included are taxa of which most or all the populations are decreasing because of over-exploitation, extensive destruction of habitat or other environmental disturbance; taxa with populations that have been seriously depleted and whose ultimate security is not yet assured; and taxa with populations that are still abundant but are under threat from serious adverse factors throughout their range.

(5) Rare (R): Taxa with small world populations that are not at present Endangered or Vulnerable, but are at risk. These taxa are usually localized within restricted geographic areas or habitats or are thinly scattered over a more extensive range.

(6) Indeterminate (I): Taxa known to be Extinct, Endangered, Vulnerable, or Rare but where there is not enough information to say which of these four categories is appropriate.

For each of these categories, the ornamental plants are arranged alphabetically by genus names (Tables 1-6). The number of plant species in the different families and the percentage of threatened plants was added for each family from the Red List of Threatened Plants IUCN (2001), and per thousands of threatened ornamental plants was calculated (Table 7).

3 Results

The result of this study is presented in tables 1-6. The species in the category of Extinct (Ex.) (Table 1) have to be considered as extinct in the wild (see fig.1). They still exist under cultivation in South Africa. Some of them are not rare in collections, e.g. in Europe, as *Tacitus bellus*, *Holarrhena pubescens* (ALEXANDER and WATSON, 2000) and *Franklinia alatamaha* (WHITEFOARD, 1995), (see table 2) appear in the European Garden Flora.

Table 1: Extinct (Ex) ornamental plants

Taxa	*Family*
Astragalus robbinsii (Oakes) A.Gray var. *robbinsii*	Leguminosae
Encephalartos woodii Sander	Zamiaceae
Erica verticillata P.J.Bergius	Ericaceae
Holarrhena pubescens (Buch.-Ham.) Wall. ex G. Don	Apocynaceae
Pitcairnia undulata Scheidw.	Bromeliaceae
Tacitus bellus Moran & J.Meyrán	Crassulaceae

Table 2: Extinct/Endangered (Ex/E) ornamental plants

Taxa	*Family*
Franklinia alatamaha Bartr. ex Marsh.	Theaceae
Pritchardia affinis Becc.	Palmae

Compared with the results on crop plant species overlapping of both lists, ornamental plants are sometimes used for other purposes, crop plants become ornamental ones after giving up crop production. Several multi-purpose plants can be found in different categories. As an example *Juglans hindsii*, from the Endangered group (see table 3) might be considered. It is planted in North America as road and shade tree. It is used as a rootstock for *J. regia* because of its disease resistance and vigour. The edible nuts are produced on a small-scale commercial basis in Missouri and Indiana and are traded occasionally on the American markets (KELLER, 2001). In this category Zamiaceae (14), Palmae (21) and Bromeliaceae (16) are frequent. Bromeliaceae are typical objects for collection similar to Orchidaceae and succulents (Agavaceae, Aloaceae, Cactaceae, Aizoaceae).

Table 3: Endangered (E) ornamental plants

Taxa	*Family*
Agave wercklei Weber ex Werckle	Agavaceae
Aloe albiflora Guillaumin	Aloaceae
Aloe ballii Reynolds	Aloaceae
Aloe bellatula G. Reynolds	Aloaceae
Araucaria rulei F. Muell.	Araucariaceae
Areca concinna Thwaites	Palmae
Astrophytum asterias (Zucc.) Lem.	Cactaceae
Atriplex canescens (Pursh)Nutt. var. *gigantea* Welsh & Stutz	Chenopodiaceae
Balfourodendron riedelianum Engl.	Rutaceae
Beccariophoenix madagascariensis Jum. & H. Perrier	Palmae
Brahea edulis S.Watson	Palmae
Brighamia insignis Gray	Campanulaceae
Butia campicola Barb. Rodr.	Palmae
Ceratozamia hildae Landry & M. Wilson	Zamiaceae
Chamaedorea brachypoda Standley & Steyerm.	Palmae
Coccothrinax crinita Becc. ssp. *crinita*	Palmae
Columnea allenii Mort.	Gesneriaceae
Cupressus goveniana Gord.	Cupressaceae
Cypella herberti (Lindley) Herbert	Iridaceae
Dypsis decipiens (Becc.) Beentje & J. Dransf.	Palmae
Encephalartos arenarius R.A.Dyer	Zamiaceae
Encephalartos cerinus Lavranos & D.L.Goode	Zamiaceae
Encephalartos chimanimaniensis R.A.Dyer & I.Verd.	Zamiaceae
Encephalartos concinnus R.A.Dyer & I.Verd.	Zamiaceae
Encephalartos cupidus R.A.Dyer	Zamiaceae
Encephalartos dolomiticus Lavranos & D.L.Goode	Zamiaceae
Encephalartos dyerianus Lavranos & D.L.Goode	Zamiaceae
Encephalartos inopinus R.A.Dyer	Zamiaceae
Encephalartos laevifolius Stapf & Burtt Davy	Zamiaceae
Encephalartos latifrons Lehm.	Zamiaceae
Encephalartos munchii R.A.Dyer & I.Verd.	Zamiaceae
Encephalartos pterogonus R.A.Dyer & I.Verd.	Zamiaceae
Gaussia attenuata (O.F. Cook) Becc.	Palmae
Geranium maderense Yeo	Geraniaceae
Gigasiphon macrosiphon (Harms) Brenan	Leguminosae
Grevillea caleyi R.Br.	Proteaceae
Haemanthus pumilio Jacq.	Amaryllidaceae
Hyophorbe lagenicaulis (L. Bailey) H.E. Moore	Palmae

(Table 3 continuation)

Taxa	*Family*
Hyophorbe vaughanii L. Bailey	Palmae
Hyophorbe verschaffeltii H.A. Wendl.	Palmae
Juglans hindsii (Jepson) Jepson ex R.E. Sm.	Juglandaceae
Juniperus barbadensis L.	Cupressaceae
Juniperus bermudiana L.	Cupressaceae
Juniperus cedrus Webb & Berthel.	Cupressaceae
Latania loddigesii Martius	Palmae
Latania lontaroides (Gaertner) H.E. Moore	Palmae
Lavatera phoenicea Vent.	Malvaceae
Limonium dufourei (Girard) Kuntze	Plumbaginaceae
Livistona carinensis (Chiov.) Dransf. & Uhl	Palmae
Lotus berthelotii Masf	Leguminosae
Lotus maculatus Breitfeld	Leguminosae
Malus hupehensis (Pamp.) Rehd.	Rosaceae
Malvaviscus arboreus Cav. var. *lobatus* A. Robyns	Malvaceae
Mammillaria carmenae Castaneda & Nunez	Cactaceae
Marojejya darianii J. Dransf. & N. Uhl	Palmae
Melocactus matanzanus Leon	Cactaceae
Metasequoia glyptostroboides Hu & Cheng	Taxodiaceae
Neoveitchia storckii (H.A. Wendl.) Becc.	Palmae
Nepenthes gracillima Ridley	Nepenthaceae
Orania trispatha (J. Dransf. & N.W. Uhl) Beentje & J. Dransf.	Palmae
Paphiopedilum armeniacum S.C. Chen & F.Y. Liu	Orchidaceae
Paphiopedilum micranthum Tang & Wang	Orchidaceae
Pinanga javana Blume	Palmae
Pinus maximartinezii Rzedowski	Pinaceae
Pinus muricata D. Don var. *muricata*	Pinaceae
Pinus radiata D. Don var. *radiata*	Pinaceae
Pinus torreyana Parry ex Carr.	Pinaceae
Pleiospilos simulans (Marloth) N.E.Br.	Aizoaceae
Pritchardia remota Becc.	Palmae
Puya laxa L.B. Smith	Bromeliaceae
Puya macrura Mez	Bromeliaceae
Sabal bermudana L.H. Bailey	Palmae
Sedum obtusatum A. Gray ssp. *paradisum* Denton	Crassulaceae
Teline nervosa A. Hansen & Sunding	Leguminosae
Tillandsia balsasensis Rauh	Bromeliaceae
Tillandsia califanii Rauh	Bromeliaceae
Tillandsia hildae Rauh	Bromeliaceae
Tillandsia hondurensis Rauh	Bromeliaceae
Tillandsia ignesiae Mez	Bromeliaceae
Tillandsia ixioides Grisebach	Bromeliaceae
Tillandsia kammii Rauh	Bromeliaceae
Tillandsia lindenii Regel var. *lindenii*	Bromeliaceae
Tillandsia magnusiana Wittmack	Bromeliaceae
Tillandsia matudae Lyman B. Smith	Bromeliaceae
Tillandsia nuptialis Braga & Sucre	Bromeliaceae
Tillandsia plumosa Baker	Bromeliaceae
Tillandsia reuteri Rauh	Bromeliaceae
Veitchia montgomeryana H.E. Moore	Palmae

(Table 3 continuation)

Taxa	*Family*
Vriesea harmsiana (Lyman B. Smith) Lyman B. Smith	Bromeliaceae
Widdringtonia cedarbergensis Marsh	Cupressaceae
Widdringtonia schwarzii (Marloth) Mast.	Cupressaceae
Zamia vasquezii D. Stevenson	Zamiaceae

The Vulnerable category (Table 4) is the second large group in the threatened ornamentals. Some important multi-purpose plants in this group are *Dimocarpus longan*, *Jubaea chilensis*, *Lodoicea maldivica*, *Macadamia ternifolia*, *M. tetraphylla*, *Origanum dictamnus*, *Syzygium paniculatum*, *Warburgia salutaris*. In this category Palmae (26) and Zamiaceae (17) are rather frequent.

Table 4: Vulnerable (V) ornamental plants

Taxa	*Family*
Acacia flocktoniae Maiden	Leguminosae
Acacia koaia Hbd.	Leguminosae
Acanthophoenix rubra (Bory) H.A. Wendl.	Palmae
Aeonium sedifolium (Webb ex Bolle) Pit. & Proust	Crassulaceae
Allagoptera arenaria (Gomes) Kuntze	Palmae
Araucaria heterophylla (Salisb.) Franco	Araucariaceae
Argyranthemum broussonetii (Pers.) Humphries ssp. *broussonetii*	Compositae
Ariocarpus fissuratus (Engelm.) Britton & Rose var. *lloydii* (Rose) W.T. Marsh	Cactaceae
Armeria welwitschii Boiss.	Plumbaginaceae
Astrophytum capricorne (A. Dietr.) Britton & Rose var. *capricorne*	Cactaceae
Azorina vidalii (H.C.Watson) Feer	Campanulaceae
Begonia cubensis Hassk.	Begoniaceae
Bentinckia nicobarica (Kurz) Becc.	Palmae
Caesalpinia echinata Lam.	Leguminosae
Callitris oblonga A.Rich. & Rich.	Cupressaceae
Calophyllum calaba L. var. calaba	Guttiferae
Carpenteria californica Torr.	Hydrangeaceae
Ceanothus cyaneus Eastw.	Rhamnaceae
Ceanothus dentatus Torr. & Gray	Rhamnaceae
Cedrus brevifolia (Hook.f.) Henry	Pinaceae
Cephalocereus senilis (Haw.) Pfeiffer	Cactaceae
Cephalotaxus hainanensis Li	Cephalotaxaceae
Ceratozamia kuesteriana Regel	Zamiaceae
Ceratozamia norstogii D. Stevenson	Zamiaceae
Chamaedorea graminifolia H. Wendl.	Palmae
Chamaedorea microspadix Burret	Palmae
Chamaedorea radicalis C. Martius	Palmae
Cheiridopsis peculiaris N.E.Br.	Aizoaceae
Chorizema varium Benth.	Leguminosae
Cupressus bakeri Jepson	Cupressaceae
Cupressus cashmeriana Royle ex Carrière	Cupressaceae
Cycas ophiolitica K.Hill	Cycadaceae

(Table 4 continuation)

Taxa	*Family*
Cycas taiwaniana Carruth.	Cycadaceae
Cyrtanthus brachysiphon Hilliard & B.L.Burtt	Amaryllidaceae
Deckenia nobilis H.A. Wendl.	Palmae
Dianthus serotinus Waldst. & Kit.	Caryophyllaceae
Dierama pulcherrimum (Hook.f.) Baker	Iridaceae
Dimocarpus longan Lour.	Sapindaceae
Dioon mejiae Standley & L.O. Williams	Zamiaceae
Dioscorea elephantipes (L'Hér.) Engl.	Dioscoreaceae
Dodonaea rupicola C.White	Sapindaceae
Drosera adelae F.Muell.	Droseraceae
Dypsis decaryi (Jum.) Beentje & J. Dransf.	Palmae
Dypsis hildebrandtii Becc.	Palmae
Dypsis jumelleana Beentje & J. Dransf.	Palmae
Dypsis louvelii Jum. & H. Perrier	Palmae
Dypsis rivularis (Jum. & H. Perrier) Beentje & J. Dransf.	Palmae
Echium pininana Webb & Berthel.	Boraginaceae
Encephalartos altensteinii Lehm.	Zamiaceae
Encephalartos caffer (Thunb.) Lehm.	Zamiaceae
Encephalartos cycadifolius (Jacq.) Lehm.	Zamiaceae
Encephalartos eugene-maraisii I.Verd.	Zamiaceae
Encephalartos friderici-guilielmi Lehm.	Zamiaceae
Encephalartos ghellinckii Lem.	Zamiaceae
Encephalartos gratus Prain	Zamiaceae
Encephalartos horridus (Jacq.) Lehm.	Zamiaceae
Encephalartos humilis I.Verd.	Zamiaceae
Encephalartos longifolius (Jacq.) Lehm.	Zamiaceae
Encephalartos ngoyanus I.Verd.	Zamiaceae
Encephalartos paucidentatus Stapf & Burtt Davy	Zamiaceae
Encephalartos princeps R.A.Dyer	Zamiaceae
Encephalartos trispinosus (Hook.) R.A.Dyer	Zamiaceae
Encephalartos umbeluziensis R.A.Dyer	Zamiaceae
Erica bauera Andrews	Ericaceae
Erythronium tuolumnense Applegate	Liliaceae
Eucalyptus argophloia Blakely	Myrtaceae
Eucalyptus burdettiana Blakely & Steedman	Myrtaceae
Eucalyptus nicholii Maiden & Blakely	Myrtaceae
Eucalyptus pulverulenta Sims	Myrtaceae
Eucalyptus scoparia Maiden	Myrtaceae
Furcraea bedinghausii K. Koch	Agavaceae
Gastrochilus japonicus (Makino) Schltr.	Orchidaceae
Gaussia maya (Cook) Quero & R. W. Read	Palmae
Genista tinctoria L. ssp. *prostrata* Corillion, Figureau, Godeau	Leguminosae
Haemanthus amarylloides Jacq. ssp. *amarylloides*	Amaryllidaceae
Hedyscepe canterburyana (C. Moore & F. Muell.) H. Wendl.	Palmae
Heliconia angusta Vell.	Heliconiaceae
Hyophorbe indica Gaertner	Palmae
Jasminum azoricum L.	Oleaceae
Jubaea chilensis (Mol.) Baillon	Palmae
Jubaeopsis caffra Becc.	Palmae
Juniperus recurva Buch-Ham. ex D. Don var. *coxii* (Jacks.) Melville	Cupressaceae

(Table 4 continuation)

Taxa	*Family*
Kennedia macrophylla (Meisner) Benth.	Leguminosae
Laelia furfuracea Lindley	Orchidaceae
Latania verschaffeltii Lemaire	Palmae
Leucadendron daphnoides (Thunb.) Meisn.	Proteaceae
Leucadendron galpinii E.Phillips & Hutch.	Proteaceae
Leucospermum formosum (Andrews) Sweet	Proteaceae
Leucospermum fulgens Rourke	Proteaceae
Leucospermum grandiflorum (Salisb.) R.Br.	Proteaceae
Leucospermum parile (Salisb. ex Knight) Sweet	Proteaceae
Libocedrus plumosa (D. Don) Sarg.	Cupressaceae
Limonium perezii (Stapf) Hubbard	Plumbaginaceae
Livistona drudei F.Muell. ex W.Watson	Palmae
Lodoicea maldivica (J. Gmelin) Pers.	Palmae
Lyonothamnus floribundus A.Gray ssp. *aspleniifolius* (Greene) Raven	Rosaceae
Lythrum flexuosum Lag.	Lythraceae
Macadamia integrifolia Maiden & Betche	Proteaceae
Macadamia ternifolia F.Muell.	Proteaceae
Macadamia tetraphylla L.A.S.Johnson	Proteaceae
Mammillaria bocasana Poselger	Cactaceae
Marojejya insignis Humbert	Palmae
Masdevallia instar Luer & Andreetta	Orchidaceae
Mimetes hirtus (L.) Salisb. ex Knight	Proteaceae
Nephrosperma vanhoutteanum (Wendl. ex Van Houtte) Balf. f.	Palmae
Normanbya normanbyi (A.W.Hill) L.H.Bailey	Palmae
Ocotea porosa (Nees & Martius) Barroso	Lauraceae
Oncidium phalaenopsis Lindley	Orchidaceae
Opuntia whipplei Engelm. & Bigelow	Cactaceae
Origanum dictamnus L.	Labiatae
Paranomus reflexus (E.Phillips & Hutch.) N.E.Br.	Proteaceae
Phalaenopsis schilleriana Reichb.f.	Orchidaceae
Phoenicophorium borsigianum (K. Koch) Stuntz	Palmae
Phoenix rupicola T. Anders.	Palmae
Phoenix theophrasti Greuter	Palmae
Picea omorika (Pancic) Purk.	Pinaceae
Pinus muricata D. Don	Pinaceae
Pinus occidentalis Sw.	Pinaceae
Prosopis tamarugo Philippi	Leguminosae
Psoralea arborea Sims	Leguminosae
Reutealis trisperma (Blanco) Airy Shaw	Euphorbiaceae
Roystonea elata (Bartr.) F. Harper	Palmae
Salix magnifica Hemsl.	Salicaceae
Sciadopitys verticillata (Thunb. ex J.A. Murray) Sieb. & Zucc.	Taxodiaceae
Sequoiadendron giganteum (Lindl.) Buchh.	Taxodiaceae
Sequoia wellingtonia Seem.	Taxodiaceae
Serruria florida (Thunb.) Salisb. ex Knight	Proteaceae
Sparaxis elegans (Sweet) Goldblatt	Iridaceae
Sparaxis tricolor (Schneev.) Ker Gawl.	Iridaceae
Stanhopea hernandezii (Kunth) Schltr.	Orchidaceae
Stanhopea tigrina Bateman ex Lindley	Orchidaceae
Strongylodon macrobotrys A.Gray	Leguminosae

(Table 4 continuation)

Taxa	*Family*
Syzygium paniculatum Gaertner	Myrtaceae
Tanacetum ptarmiciflorum (Webb) Schultz Bip.	Compositae
Tillandsia baileyi Rose ex Small	Bromeliaceae
Tillandsia butzii Mez	Bromeliaceae
Tillandsia caput-medusae E. Morren	Bromeliaceae
Tillandsia heterophylla E. Morren	Bromeliaceae
Tillandsia ionantha Planchon	Bromeliaceae
Tillandsia pueblensis Lyman B. Smith var. *pueblensis*	Bromeliaceae
Tillandsia selleana Harms	Bromeliaceae
Tillandsia streptophylla Scheidw. ex Morren	Bromeliaceae
Tillandsia superba Mez & Sodiro	Bromeliaceae
Verschaffeltia splendida H.A. Wendl.	Palmae
Warburgia salutaris (Bertol.f.) Chiov.	Canellaceae
Zamia fischeri Miq.	Zamiaceae
Zamia splendens Schutzman	Zamiaceae

The largest group in our study is the Rare category (see table 5). In this category are many multipurpose species such as *Dioon edule, Eucalyptus macarthurii, Euterpe edulis, Pimpinella anisetum and Rheum rhaponticum*.
Corypha umbraculifera is a multi-purpose ornamental palm tree. The leaves serve for the production of fans, mats, umbrellas, and baskets or are used (especially formerly) as writing materials. The leaf stalks are made into paper. The pith of the stems is the source of a sago-like product. The hard seeds are manufactured into buttons and jewellery (Kruse, 2001).

Table 5: Rare (R) ornamental plants

Taxa	*Family*
Abies pinsapo Boiss. var. *pinsapo*	Pinaceae
Abromeitiella brevifolia (Grisebach) Castellanos	Bromeliaceae
Acacia howittii F.Muell.	Leguminosae
Acacia iteaphylla Benth.	Leguminosae
Acacia jonesii F.Muell. & Maiden	Leguminosae
Acacia quornensis J.Black	Leguminosae
Acacia robynsiana Merxm. & A.Schreib.	Leguminosae
Acaena novae-zelandiae Kirk	Rosaceae
Adansonia za Baillon	Bombaceae
Aechmea blumenavii Reitz	Bromeliaceae
Aechmea kleinii Reitz	Bromeliaceae
Agathis atropurpurea B.Hyland	Araucariaceae
Agathis microstachya J.F.Bailey & C.White	Araucariaceae
Agathosma pulchella (L.) Link	Rutaceae
Alberta magna E.Mey.	Rubiaceae
Alloxylon pinnatum (Maiden & Betche) P.Weston & Crisp	Proteaceae
Aloe forbesii Balf. f.	Aloaceae
Alyssum wulfenianum Bernh.	Cruciferae
Anacampseros filamentosa (Haw.) Sims ssp. *filamentosa*	Portulacaceae
Anthemis sancti-johannis Stoj., Stef. & Turrill	Compositae
Aporocactus flagelliformis (L.) Lemaire	Cactaceae

(Table 5 continuation)

Taxa	*Family*
Aquilegia eximia Van Houtte ex Planch.	Ranunculaceae
Aquilegia longissima Gray	Ranunculaceae
Arabis ferdinandi-coburgi Kellerer & Sünd.	Cruciferae
Araucaria angustifolia (Bertol.) Kuntze	Araucariaceae
Araucaria araucana (Mol.) K. Koch	Araucariaceae
Areca guppyana Becc.	Palmae
Argyranthemum webbii Schultz Bip.	Compositae
Aruncus dioicus Fern. var. *subrotundus* Hara	Rosaceae
Aztekium ritteri (Boed.) Boed.	Cactaceae
Ballota pseudodictamnus (L.) Benth.	Labiatae
Bauhinia bowkeri Harv.	Leguminosae
Begonia dregei Otto & A.Dietr.	Begoniaceae
Bolusiella maudiae (Bolus) Schltr.	Orchidaceae
Bowkeria citrina Thode	Scrophulariaceae
Brunfelsia undulata Sw.	Solanaceae
Burretiokentia vieillardii (Brongn. & Gris) Pichi-Serm.	Palmae
Calothamnus rupestris Schauer	Myrtaceae
Calycanthus occidentalis Hook. & Arn.	Calycanthaceae
Calyptronoma occidentalis (Sw.) H.E. Moore	Palmae
Campanula davisii Turrill	Campanulaceae
Campanula elatinoides Moretti	Campanulaceae
Campanula incurva Aucher ex A.DC.	Campanulaceae
Campanula portenschlagiana Schult.	Campanulaceae
Campanula poscharskyana Degen	Campanulaceae
Carex oshimensis Nakai	Cyperaceae
Cassia splendida Vog.	Leguminosae
Ceanothus arboreus Greene	Rhamnaceae
Ceanothus lemmonii Parry	Rhamnaceae
Ceanothus papillosus Torr. & Gray	Rhamnaceae
Ceratozamia robusta Miq.	Zamiaceae
Chamaecyparis formosensis Matsum.	Cupressaceae
Chamaecyparis lawsoniana (A. Murr.) Parl.	Cupressaceae
Chamaedorea klotzschiana H. Wendl.	Palmae
Chambeyronia macrocarpa Vieill. ex Becc.	Palmae
Clarkia purpurea (W. Curtis) A. Nels. & J.F. Macbr.	Onagraceae
Coelogyne cristata Lindley	Orchidaceae
Coreopsis maritima (Nutt.) Hook. f.	Compositae
Corypha umbraculifera L.	Palmae
Crinodendron hookeranum Gay	Elaeocarpaceae
Crinum campanulatum Herb.	Amaryllidaceae
Cryptomeria japonica (L. f.) D. Don var. *japonica*	Taxodiaceae
Cupressus lusitanica Mill. var. *benthamii* (Endl.) Carrière	Cupressaceae
Cupressus sargentii Jepson	Cupressaceae
Cycas seemannii A. Br.	Cycadaceae
Cyphophoenix nucele H.E. Moore	Palmae
Davidia involucrata Baillon var. *involucrata*	Cornaceae
Dendrobium wassellii S.T.Blake	Orchidaceae
Dianthus gallicus Pers.	Caryophyllaceae
Dianthus knappii (Pant.) Asch. & Kanitz ex Borbás	Caryophyllaceae
Dianthus spiculifolius Schur	Caryophyllaceae
Dietes bicolor (Steud.) Sweet ex Klatt	Iridaceae

(Table 5 continuation)

Taxa	*Family*
Dionaea muscipula Ellis	Droseraceae
Dioon edule Lindley	Zamiaceae
Dioon spinulosum Dyer	Zamiaceae
Drosera capillaris Poir.	Droseraceae
Drymophloeus pachycladus (Burret) H.E. Moore	Palmae
Drymophloeus subdistichus (H.E. Moore) H.E. Moore	Palmae
Dypsis madagascariensis (Becc.) Beentje & J. Dransf.	Palmae
Echium wildpretii H. Pearson ex Hook.f.	Boraginaceae
Encephalartos ferox Bertol.f.	Zamiaceae
Encephalartos lanatus Stapf & Burtt Davy	Zamiaceae
Encephalartos lehmannii Lehm.	Zamiaceae
Encephalartos manikensis (Gilliland) Gilliland	Zamiaceae
Encephalartos natalensis R.A.Dyer & I.Verd.	Zamiaceae
Encephalartos tegulaneus Melville	Zamiaceae
Encephalartos transvenosus Stapf & Burtt Davy	Zamiaceae
Episcia punctata (Lindley) Hanst.	Gesneriaceae
Erica propendens Andrews	Ericaceae
Erodium manescavi Coss.	Geraniaceae
Erodium pelargoniiflorum Boiss. & Heldr.	Geraniaceae
Eucalyptus caesia Benth. ssp. *caesia*	Myrtaceae
Eucalyptus caesia Benth. ssp. *magna* Brooker & Hopper	Myrtaceae
Eucalyptus dunnii Maiden	Myrtaceae
Eucalyptus lansdowneana F.Muell. & J.E.Brown ssp. *lansdowneana*	Myrtaceae
Eucalyptus leptoloma Brooker & A.R.Bean	Myrtaceae
Eucalyptus luehmanniana F.Muell.	Myrtaceae
Eucalyptus macarthurii Deane & Maiden	Myrtaceae
Eucalyptus neglecta Maiden	Myrtaceae
Eucalyptus risdonii Hook.f.	Myrtaceae
Eucalyptus rudderi Maiden	Myrtaceae
Eucalyptus rummeryi Maiden	Myrtaceae
Eucalyptus stoatei C.Gardner	Myrtaceae
Eucalyptus yarraensis Maiden & Cambage	Myrtaceae
Eucalyptus youmanii Blakely & McKie	Myrtaceae
Eugenia zeyheri Harv.	Myrtaceae
Euterpe edulis Mart.	Palmae
Fosterella penduliflora (C.H. Wright) L.B. Smith	Bromeliaceae
Fothergilla major (Sims) Lodd.	Hamamelidaceae
Fremontodendron mexicanum A. Davids	Sterculiaceae
Geranium canariense Reuter	Geraniaceae
Ginkgo biloba L.	Ginkgoaceae
Gladiolus oppositiflorus Herbert ssp. *oppositiflorus*	Iridaceae
Gladiolus varius Bolus f. var. *varius*	Iridaceae
Greyia flanaganii Bolus	Greyiaceae
Guzmania erythrolepis Brongn. ex Planch.	Bromeliaceae
Heuchera hallii Gray	Saxifragaceae
Horkelia frondosa (Greene) Rydb.	Rosaceae
Howea belmoreana (C. Moore & F. Muell.) Becc.	Palmae
Howea forsteriana (C. Moore & F. Muell.) Becc.	Palmae
Hypericum polyphyllum Boiss. & Bal. ssp. *polyphyllum*	Guttiferae
Impatiens flanaganiae Hemsl.	Balsaminaceae
Isoplexis canariensis (L.) Loud.	Scrophulariaceae

(Table 5 continuation)

Taxa	*Family*
Jacaranda mimosifolia D. Don	Bignoniaceae
Kniphofia ensifolia Baker ssp. *autumnalis* Codd	Asphodelaceae
Kolkwitzia amabilis Graebner	Caprifoliaceae
Lafoensia pacari St.-Hil.	Lythraceae
Lavatera acerifolia Cav.	Malvaceae
Lecythis lanceolata Poiret	Lecythidaceae
Leucadendron argenteum (L.) R.Br.	Proteaceae
Leucadendron nobile I.Williams	Proteaceae
Leuchtenbergia principis Hooker	Cactaceae
Leucospermum muirii E.Phillips	Proteaceae
Leucospermum saxosum S.Moore	Proteaceae
Liquidambar orientalis Miller var. *orientalis*	Hamamelidaceae
Liriodendron chinense (Hemsley) Sarg.	Magnoliaceae
Lithops lesliei (N.E.Br.) N.E.Br. ssp. *burchellii* D.T.Cole	Aizoaceae
Livistona alfredii F.Muell.	Palmae
Mammillaria matudae H. Bravo-Holl.	Cactaceae
Manihot leptopoda (Mueller von Argau) Rogers & Appan	Euphorbiaceae
Merremia dissecta (Jacq.) Hallier f.	Convolvulaceae
Meryta sinclairii (Hook. f.) Seem.	Araliaceae
Monadenium coccineum Pax	Euphorbiaceae
Moringa drouhardii Jum.	Moringaceae
Musschia aurea (L.f.) DC.	Campanulaceae
Myosotidium hortensia (Decne.) Baillon	Boraginaceae
Nemesia strumosa Benth.	Scrophulariaceae
Nepenthes burkei Masters var. *burkei*	Nepenthaceae
Nerine pudica Hook.f.	Amaryllidaceae
Ocotea foetens (Aiton) Benth. & Hook.f.	Lauraceae
Orania longisquama (Jum.) J. Dransf. & N. Uhl.	Palmae
Pancratium canariense Ker-Gawl.	Amaryllidaceae
Paphiopedilum hirsutissimum (Lindley & Hook.) Stein	Orchidaceae
Paphiopedilum philippinense (Reichb. f.) Stein var. *roebelenii* (Veitch) Cribb	Orchidaceae
Paranomus spicatus (P.J.Bergius) Kuntze	Proteaceae
Parmentiera cereifera Seem.	Bignoniaceae
Pereskia bahiensis Gürke	Cactaceae
Physokentia dennisii H.E. Moore	Palmae
Pimpinella anisetum Boiss. & Bal.	Umbelliferae
Pinus canariensis Sweet ex Spreng.	Pinaceae
Pinus chihuahuana Engelm.	Pinaceae
Pinus greggii Engelm.	Pinaceae
Pinus lawsonii Roezl ex Gordon & Glend.	Pinaceae
Pinus luchuensis Mayr	Pinaceae
Pinus lumholtzii Robinson & Fernald	Pinaceae
Pinus oocarpa Mart. var. *trifoliata* Mart.	Pinaceae
Pitcairnia andreana Linden	Bromeliaceae
Pitcairnia punicea Scheidweiler	Bromeliaceae
Platycladus orientalis (L.f.) Franco	Cupressaceae
Plectranthus elegans Britten	Labiatae
Plectranthus oertendahlii T.C.E.Fr.	Labiatae
Polygala hispida (Burch.) DC.	Polygalaceae
Pritchardia thurstonii F. Muell. & Drude	Palmae

(Table 5 continuation)

Taxa	*Family*
Pseudotsuga macrocarpa (Vasey) Mayr	Pinaceae
Ptychosperma gracile Labill.	Palmae
Raphia australis Oberm. & Strey	Palmae
Ravenea robustior Jumelle & H. Perrier	Palmae
Rheum rhaponticum L.	Polygonaceae
Rhopaloblaste elegans H.E. Moore	Palmae
Rhopalostylis baueri (Hook.f.) H.A. Wendl. & Drude var. *baueri*	Palmae
Rhus batophylla Codd	Anacardiaceae
Romneya coulteri Harvey	Papaveraceae
Roystonea borinquena O.F. Cook	Palmae
Sabal uresana Trel.	Palmae
Sarracenia leucophylla Raf.	Sarraceniaceae
Sarracenia rubra Walt.	Sarraceniaceae
Schinus terebinthifolius Raddi	Anacardiaceae
Sedum hispanicum L. var. *planifolium* Chamb.	Crassulaceae
Serruria candicans R.Br.	Proteaceae
Sideritis candicans Aiton	Labiatae
Sonchus acaulis Dum. Cours.	Compositae
Sparaxis grandiflora (D.Delaroche) Ker Gawl ssp. *grandiflora*	Iridaceae
Stangeria eriopus (Kunze) Baill.	Stangeriaceae
Sterculia alexandri Harv.	Sterculiaceae
Strelitzia juncea Link	Strelitziaceae
Swartzia langsdorffii Raddi	Leguminosae
Tanacetum ferulaceum (Webb) Schultz Bip.	Compositae
Taxodium mucronatum Ten.	Taxodiaceae
Tecoma guarume A. de Candolle	Bignoniaceae
Terminalia bentzoë (L.) L. f. ssp. *bentzoë*	Combretaceae
Tetraclinis articulata (Vahl) Mast.	Cupressaceae
Thrinax excelsa Lodd.	Palmae
Tillandsia heteromorpha Rauh	Bromeliaceae
Tylecodon decipiens Toelken	Crassulaceae
Umtiza listeriana Sim	Leguminosae
Veitchia joannis H.A. Wendl.	Palmae
Washingtonia filifera (L. Linden) H. Wendl.	Palmae
Zamia amplifolia Hort. ex Masters	Zamiaceae
Zamia paucijuga Wieland	Zamiaceae
Zantedeschia pentlandii (Watson) Wittm.	Araceae

The Indeterminate category (see table 6) also presents some multi-purpose plants such as *Ageratum houstonianum* that is widely cultivated as an ornamental and with *Centrosema* sp. as a ground cover plant in rubber plantations in Indonesia. *Cinnamomum glanduliferum* is planted as shade tree in tea plantations as well as medicine and spice. The wood, smelling like sassafras, is utilized in carpentry, shipbuilding and for tools. *Delonix regia* in the tropics widely planted as an ornamental plant as well as support for *Piper nigrum* and shade tree (Kruse, 2001). The largest families in this category are Orchidaceae (7), Palmae (10), and Cactaceae (5).

Table 6: Indeterminate (I) ornamental plants

Taxa	*Family*
Aechmea orlandiana Lyman B. Smith var. *orlandiana*	Bromeliaceae
Aerides vandara Reichb.	Orchidaceae
Ageratum houstonianum Mill.	Compositae
Amherstia nobilis Wallich	Leguminosae
Aristolochia brevilabris Bornm.	Aristolochiaceae
Astrophytum ornatum (DC.) A. Weber	Cactaceae
Babiana hypogaea Burch. var. *longituba* G.J.Lewis	Iridaceae
Butia eriospatha (Mart. ex Drude) Becc.	Palmae
Caryota no Becc.	Palmae
Cattleya trianae Linden & Reichb.f.	Orchidaceae
Ceiba insignis (Kunth) Gibbs & Semir	Bombacaceae
Ceratozamia mexicana Brongn.	Zamiaceae
Chamaedorea geonomiformis H. Wendl.	Palmae
Cinnamomum glanduliferum Meiss.	Lauraceae
Coccothrinax miraguama (Kunth) Leon	Palmae
Cotoneaster simonsii Baker	Rosaceae
Crocosmia masonorum (L.Bolus) N.E.Br.	Iridaceae
Delonix regia (Bojer ex Hook.) Raf.	Leguminosae
Embreea rodigasiana (Claes. ex Cogn.) Dodson	Orchidaceae
Epithelantha micromeris Britton & Rose var. *greggii* (Engelm.) Borg	Cactaceae
Hatiora gaertneri (Reg.) Barthlott	Cactaceae
Hatiora rosea (Lagerh.) Barthlott	Cactaceae
Lobelia valida L.Bolus	Campanulaceae
Oncidium papilio Lindley	Orchidaceae
Orania sylvicola (Griff.) H.E. Moore	Palmae
Paphiopedilum philippinense (Reichb. f.) Stein	Orchidaceae
Paphiopedilum randsii Fowlie	Orchidaceae
Paphiopedilum sukhakulii Schoser & Senghas	Orchidaceae
Philodendron aff. scandens C. Koch & H. Sello	Araceae
Pinanga maculata Porte ex Lem.	Palmae
Pseudophoenix sargentii H.A. Wendl. ex Sarg. ssp. *sargentii*	Palmae
Reinhardtia simplex (H. Wendl.) Drude ex Dammer	Palmae
Renanthera imschootiana Rolfe	Orchidaceae
Rhipsalis pilocarpa Loefgr.	Cactaceae
Rhopalostylis sapida H. Wendl. & Drude	Palmae
Siphonochilus aethiopicus (Schweinf.) B.L.Burtt	Zingiberaceae
Veitchia merrillii (Becc.) Moore	Palmae

4 Summarized Results

The summarized results of our studies are shown in table 7. Highest percentages of threatened ornamental plants are found in the smallest families. Large families ($\geq$ 100-1000 species) rarely exceed 5 ‰; Agavaceae 5.3 ‰, Aloaceae 5.7 ‰, Amaryllidaceae 6.7 ‰, Cornaceae 10 ‰, Crassulaceae 5.6 ‰, Droseraceae 30 ‰, Geraniaceae 5.7 ‰, Hamamelidaceae 20 ‰, Myrtaceae 7 ‰, Pinaceae 68 ‰, Plumbaginaceae 10 ‰, Proteaceae 20 ‰, Ranunculaceae 5.6 ‰. Very large families with more than 1000 species have usually lower numbers of threatened species. Exceptions are Bromeliaceae – 17.5 ‰, Cactaceae – 12.7 ‰ and Palmae – 29.30 ‰. There is a weak positive correlation ($r = +0.36$) between the number of threatened species and the number of threatened ornamental species within the families.

Table 7: Number of threatened plant species in different categories, threatened crop species per thousands, number of all species and percent of threatened species in each families.

Family	*Ex.*	*Ex./E.*	*E.*	*V.*	*R.*	*I.*	*No. of threatened species*	*‰ threatened ornamentals*	*No. of all species*
Agavaceae	-	-	1	1	-	-	2	5.3	380
Aizoaceae	-	-	1	1	1	-	3	1.2	2,500
Aloaceae	-	-	3	-	1	-	4	5.7	700
Amaryllidaceae	-	-	1	2	3	-	6	6.7	900
Anacardiaceae	-	-	-	-	2	-	2	3.3	600
Apocynaceae	1	-	-	-	-	-	1	0.5	2,000
Araceae	-	-	-	-	1	1	2	1.1	1,800
Araliaceae	-	-	-	-	1	-	1	1.4	700
Araucariaceae	-	-	1	1	4	-	6	158	38
Aristolochiaceae	-	-	-	-	-	1	1	1.7	600
Asphodelaceae	-	-	-	-	1	-	1	3.1	319
Balsaminaceae	-	-	-	-	1	-	1	2.2	450
Begoniaceae	-	-	-	1	1	-	2	1.97	1,020
Bignoniaceae	-	-	-	-	3	-	3	3.8	800
Bombaceae	-	-	-	-	-	1	1	5	200
Boraginaceae	-	-	-	1	2	-	3	1.5	2,000
Bromeliaceae	1	-	16	9	8	1	35	17.5	2,000
Cactaceae	-	-	3	6	5	5	19	12.7	1,500
Calycanthaceae	-	-	-	-	1	-	1	200	5
Campanulaceae	-	-	1	1	6	1	9	4.5	2,000
Canellaceae	-	-	-	1	-	-	1	50	20
Caprifoliaceae	-	-	-	-	1	-	1	2.5	400
Caryophyllaceae	-	-	-	1	3	-	4	2	2,000
Cephalotaxaceae	-	-	-	1	-	-	1	143	7
Chenopodiaceae	-	-	1	-	-	-	1	0.7	1,500
Combretaceae	-	-	-	-	1	-	1	2.5	400
Compositae	-	-	-	2	5	1	8	0.4	20,000
Convolvulaceae	-	-	-	-	1	-	1	0.7	1,500
Cornaceae	-	-	-	-	1	-	1	10	100
Crassulaceae	1	-	1	1	2	-	5	5.6	900
Cruciferae	-	-	-	-	2	-	2	0.7	3,000
Cupressaceae	-	-	6	5	6	-	17	130.8	130
Cycadaceae	-	-	-	2	1	-	3	85.7	35
Dioscoreaceae	-	-	-	1	-	-	1	1.6	630
Droseraceae	-	-	-	1	2	-	3	30	100
Elaeocarpaceae	-	-	-	-	1	-	1	2.5	400
Ericaceae	1	-	-	1	1	-	3	0.86	3,500
Euphorbiaceae	-	-	-	1	2	-	3	0.4	7,500
Geraniaceae	-	-	1	-	3	-	4	5.7	700
Gesneriaceae	-	-	1	-	1	-	2	0.8	2,500
Ginkgoaceae	-	-	-	-	1	-	1	1000	1
Greyiaceae	-	-	-	-	1	-	1	333	3
Guttiferae	-	-	-	1	1	-	2	1.7	1,200
Hamamelidaceae	-	-	-	-	2	-	2	20	100
Heliconiaceae	-	-	-	1	-	-	1	10	100
Hydrangeaceae	-	-	-	1	-	-	1	5.9	170
Iridaceae	-	-	1	3	4	2	10	0.7	1,500

(Table 7 continuation)

Family	*Ex.*	*Ex./E.*	*E.*	*V.*	*R.*	*I.*	*No. of threatened species*	*‰ threatened ornamentals*	*No. of all species*
Juglandaceae	-	-	1	-	-	-	1	16.7	60
Labiatae	-	-	-	1	4	-	5	1.6	3,200
Lauraceae	-	-	-	1	1	1	3	1.5	2,000
Lecythidaceae	-	-	-	-	1	-	1	2.5	400
Leguminosae	1	-	4	9	9	2	25	1.9	13,100
Liliaceae	-	-	-	1	-	-	1	2.2	460
Lythraceae	-	-	-	1	1	-	2	4	500
Magnoliaceae	-	-	-	-	1	-	1	4.5	220
Malvaceae	-	-	1	-	1	-	2	1.6	1,250
Moringaceae	-	-	-	-	1	-	1	100	10
Myrtaceae	-	-	-	6	16	-	21	7	3,000
Nepenthaceae	-	-	1	-	1	-	2	26.7	75
Oleaceae	-	-	-	1	-	-	1	1.7	600
Onagraceae	-	-	-	-	1	-	1	1.5	675
Orchidaceae	-	-	2	7	5	8	22	0.7	30,000
Palmae	-	1	21	29	27	10	88	29.3	3,000
Papaveraceae	-	-	-	-	1	-	1	5	200
Pinaceae	-	-	4	4	9	-	17	68	250
Plumbaginaceae	-	1	1	2	-	-	4	10	400
Polygalaceae	-	-	-	-	1	-	1	1.3	750
Polygonaceae	-	-	-	-	1	-	1	1	1,000
Portulacaceae	-	-	-	-	1	-	1	2	500
Proteaceae	-	-	1	12	7	-	20	20	1,000
Ranunculaceae	-	-	-	-	3	-	3	1.5	2,000
Rhamnaceae	-	-	-	2	3	-	5	5.6	900
Rosaceae	-	-	1	1	3	1	6	2	3,000
Rubiaceae	-	-	-	-	1	-	1	0.15	6,500
Rutaceae	-	-	1	-	1	-	2	2	1,500
Salicaceae	-	-	-	1	-	-	1	2.9	340
Sapindaceae	-	-	-	2	-	-	2	1.3	1,500
Sarraceniaceae	-	-	-	-	2	-	2	133	15
Saxifragaceae	-	-	-	-	1	-	1	1.7	588
Scrophulariaceae	-	-	-	-	3	-	3	0.75	4,000
Solanaceae	-	-	-	-	1	-	1	0.36	2,800
Stangeriaceae	-	-	-	-	1	-	1	1000	1
Sterculiaceae	-	-	-	-	2	-	2	2	1,000
Strelitziaceae	-	-	-	-	1	-	1	142.9	7
Taxodiaceae	-	-	1	3	2	-	6	375	16
Theaceae	-	1	-	-	-	-	1	1.7	600
Umbelliferae	-	-	-	-	1	-	1	0.3	3,000
Zamiaceae	1	-	14	19	12	1	47	326.4	144
Zingiberaceae	-	-	-	-	-	1	1	1	1,000
Total	2	6	91	148	210	37	491	-	-

Ex, Extinct; Ex/En, Extinct/Endangered; E, Endangered; V, Vulnerable; R, Rare; I, Indeterminate

5 Discussion

After finishing the first comprehensive work on threatened crop plants (HAMMER and KHOSHBAKHT, 2005b) the question arose concerning threatened ornamental plants. Ornamental plants are not included in Mansfeld's Encyclopedia of Agricultural and Horticultural Crops (HANELT and IPK, 2001), which has been used as the world-wide basis for crop plants (excluding ornamentals). Mansfeld's Encyclopedia was checked against the Red List of Threatened Plants (IUCN, 2001). In principal, the same procedure was planned for the ornamental plants but for them no world-wide Encyclopedia is available. Therefore, a special calculation was necessary, taking into account different sources as Hortus Third (1976), The European Garden Flora (WALTERS *et al.*, 1986-2000), BAÑARES *et al.* (2004); CULLEN *et al.* (2000) and others.

The plant finder by ERHARDT and ERHARDT (2000) contains 50.000 species and cultivars all over Europe and the newest plant finder (DORLING KINDERSLEY, 2006) reports more than 70.000 species and cultivars. Plant finders provide the possibility to summarize all information from commercial plants and seeds lists. But there is still the question to differentiate between species and cultivars. The decision is not easy and there are only few publications that report separated or alone about the species number in ornamental plants of an area. For crop plants some data are available, e.g. from the work with checklists in Cuba (HAMMER *et al.*, 1992-1994), Italy (HAMMER, 1999) and Korea (HOANG *et al.*, 1997). This work helped to push the overall number of crop plant species in the world to more than 6.000 and supported the compilation in Mansfeld's Encyclopedia (HANELT and IPK, 2001).

A similar approach has been made by GLEN (2002) in Southern Africa. He started from 37.000 specimens he has seen of cultivated plants in this area. Therefore, the basis is much more similar to the results obtained from checklists and eventually different from figures obtained from seed catalogues and plant lists (e.g. WALTERS *et al.* (1986-2000)). The specimens of GLEN (2002) are mostly archived in the National Herbarium of South Africa, Pretoria, and thus available for scientific work.

This is the reason for taking the data as a solid basis for a first survey of threatened ornamental plants and at the same time for supporting the calculation of the total number of ornamental plants in the world. This number appears to be relatively high as can be seen from table 8.

The way to calculate the total number of cultivated ornamentals will be presented elsewhere (HAMMER and KHOSHBAKHT, in prep.). As can be seen from table 8 the total number of cultivated plant species amounts for about 35.000 species. Tree species of forest cultivation are less frequent. A compilation about cultivated forest trees was published by SCHULTZE-MOTEL (1966). New data can be found in different sources. As many of the included trees are multi-purpose trees they can be found, often in connection with agro-forestry, also in Mansfeld's Encyclopedia (HANELT and IPK, 2001).

From our work in Cuba (HAMMER *et al.*, 1992-1994) we know that crop plants are often considered also as ornamentals. When they are no longer used in their respective group of commodity, e.g. as vegetables or medicinal plants, they may still persist in the

Table 8: Number of existing (Exi.) / threatened (Thr.) higher plant species, ornamentals and cultivated plant species worldwide (after Hammer 1998, see also Hammer (1999).

Higher plant species			*Ornamental plant species*			*Crop plant species**		
Exi.	*Thr.*	*%Thr.*	*Exi.*	*Thr.*	*%Thr.*	*Exi.*	*Thr.*	*%Thr.*
250,000	33,730 †	13.5	28,000	3,900	13.9	7,000	940 ‡	13.4

* In the definition of Mansfeld's Encyclopedia; † Calculated after Lucas and Synge (1996) ‡ From Lucas and Synge (1996)

gardens as ornamentals. There is a certain overlap between crop plants and ornamentals, which should be considered when calculating the total number of these two major groups (Table 8).

Similar to the crop plants, ornamental plants show some general tendencies as explained by Hammer and Khoshbakht (2005b). Even very rare ornamental plants are presented in collections as can be seen from the tables of the first red list categories. In some cases plants already extinct in the wild get well establish in collections and many are later transfered back to the nature. These groups are shown in table 7 with a high number of threatened species (Bromeliaceae – 35, Cactaceae – 19, Orchidaceae – 22, Palmae – 88, Zamiaceae – 47).
On the other hand, extensive collection of these ornamental species was, at least in some cases, the cause of their rarity.

Successful cultivation may provide the necessary materials for human use and also for reintroduction into the wild (Hammer and Khoshbakht, 2005a). Here the practical experiences of botanical gardens can be used (Maunder, 1992; Akeroyd and Wyse Jackson, 1995). Of course, this way can be followed easily for plants with absent or on the lower levels of domestication.

Modern biotechnology has helped in the propagation of difficult ornamentals. The best-known examples are the Orchidaceae.
Contrary to the crop plants where there is a certain tendency to reduce the number of species in present use, we find the reverse trend in ornamental plants. A steadily increasing number of species is taken into cultivation to serve the growing curiosity of mankind, in making use of modern technology. An interesting example from table 3 (endangered ornamental plants) is *Brighamia insignis* Gray (Campanulaceae) from the Hawaii archipelago, a pachycaul treelet that underwent successful micropropagation within a programme of IUCN and is sold as a curiosity in many parts of world and accordingly was reported also by Glen (2002). Another good example provide carnivorous plants, which can be easily propagated with modern technology (see families

Droseraceae, Nepenthaceae, Sarraceniaceae in our lists). Rarity and curiosity become strong incentives for the hunters/gathers of our days.

Our result provides the basis for a first list of threatened ornamental plants and, at the same time, for supporting the calculation of the total number of ornamental plants in the world.

6 Conclusion

About 500 threatened ornamental plant species have been listed using the book of GLEN (2002) and the method indicated above. But there is good reason to predict a higher number (see table 8), as can be seen from our preliminary calculation.

Many efforts have been done to find effective methods for the protection of rare ornamental plants. In Great Britain "The Pink Sheet" (ANONYMOUS, 2000) is published for rare and endangered garden plants (see also HAMMER and KHOSHBAKHT (2005b)). As already stated, the numbers of garden plants comprises mostly ornamentals. Ornamental plants are often taken in the gardens and are protected there.

Sources from cultivated material can be eventually taken for the reintroduction to the wild. But also the destruction of rare material in the wild is connected with the collecting of ornamental plants. Those activities are today coined as "biopiratry". Of course, the plants are changed genetically under domestication influences and there may be problems with their reintroduction to the wild. Whereas there is a certain tendency to reduce the number of crop plant species (HAMMER, 2004), the number of ornamentals under cultivation is steadily increasing. This is not only the result of plant breeding but also of direct introduction, so that plant collecting for ornamental plant use will remain a certain problem.

The number of ornamental species has been often discussed. The plant finder (ERHARDT and ERHARDT, 2000) contains 50.000 species and cultivars which are traded all over Europe and the newest plant finder (DORLING KINDERSLEY, 2006) reports more than 70.000 species and cultivars.

From the roughly 200 species of threatened crop plants listed by HAMMER and KHOSHBAKHT (2005b), 28 also appear in the present lists (ca. 14%). This gives a first idea about the overlap of calculations between the groups of ornamental and crop plants.

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