Biodivers Conserv (2017) 26:1587–1600
DOI 10.1007/s10531-017-1319-7

ORIGINAL PAPER

Palm economic and traditional uses, evolutionary history and the IUCN Red List

Livia M. O. Laureto[1] · Marcus V. Cianciaruso[2]

Received: 2 May 2016 / Revised: 24 January 2017 / Accepted: 10 February 2017 /
Published online: 15 February 2017

Abstract The growing demand for natural resources to sustain human population has increased the loss and modification of natural habitats, enhancing the number of species threatened with extinction. Commonly tools such as Red Lists guide conservation actions and policies. However, Red Lists are based in population parameters, and important aspects of biodiversity such as phylogenetic diversity are not considered. Here we evaluated the amount of economic and traditional uses and evolutionary history of palms captured by the global IUCN Red List and the national Red Lists of Colombia and Madagascar. We estimated palms plant use diversity (PUD) and phylogenetic diversity (PD) for all species in the IUCN Red List and for each threat category at global and national scale. We also investigated if the number of uses, PUD and PD predict palm threat level. Species covered by IUCN Red List have lower PUD and PD than expected by chance. At global scale, palms with higher extinction risk have lower number of uses, PUD and PD. However, whereas in Colombia least concern species had lower PUD and PD, in Madagascar only Data Deficient species had lower PUD than expected by chance. Our findings highlight the need of palm specialists to expand the list of palms they have assessed and submit them for inclusion in Red Lists, enabling Red Lists to capture a more random sample of palm evolutionary history and economic uses. That would improve the success of biodiversity conservation actions by taking into account other aspects of biodiversity rather than taxonomic identity.

Communicated by Daniel Sanchez Mata.

Electronic supplementary material The online version of this article (doi:10.1007/s10531-017-1319-7) contains supplementary material, which is available to authorized users.

✉ Livia M. O. Laureto
lialaureto@gmail.com

1 Post-Graduate Program in Ecology and Evolution, Universidade Federal de Goiás, Goiânia, Brazil

2 Department of Ecology, Universidade Federal de Goiás, CP 131, Goiânia, GO 74001-970, Brazil

Keywords Arecaceae · Ethnobotany · Extinction risk · Phylogenetic diversity · Plant use diversity

Introduction

Palms (Arecaceae) are not only emblematic components of tropical and subtropical ecosystems but also play key ecological roles in pollinator and seed dispersal networks (Macía 2004; Dransfield et al. 2008) and facilitate forest regeneration (Salm et al. 2005). Additionally to their ecological relevance, palms are among the most useful plant species to mankind (Govaerts and Dransfield 2005). Their leaves, fruits, seeds, and fibers are used for a huge number of purposes, providing fundamental resources to traditional communities or even being commercially exploited at larger scales (Johnson 2010; Palmweb 2015). In underdeveloped regions of the world, palms are extremely important to indigenous and traditional communities (Dransfield and Beentje 1995; Henderson et al. 1995; Byg and Balslev 2001), providing construction materials, fabrics, fuel, food, medicine, and ornamentals (Balick 1988; Sosnowska and Balslev 2009; de la Torre et al. 2009). Nevertheless, despite their great importance, several palm species are at risk of extinction due to unsustainable exploitation and habitat loss (Rakotoarinivo et al. 2014).

The growing demand for natural resources to sustain human population has increased the loss and modification of natural habitats at unprecedented rates (Barnosky et al. 2011), notably in the tropics (Hansen et al. 2010). The extinction of native species associated with the introduction of new species is also reducing the biodiversity and homogenizing the biotas across the globe (Mckinney and Lockwood 1999; Chen et al. 2010; Clavel et al. 2011). This scenario not only threatens the multiple ecological roles that species perform and millions of years of accumulated genetic diversity, but also jeopardizes the dependence of humans on renewable resources and ecosystem services provided by natural landscapes (Cardinale et al. 2012). Concerns regarding biodiversity conservation caused parties of the convention on biological diversity (CBD) to establish 20 targets to be achieved in the period of 2011–2020, including the maintenance of the genetic diversity of "socio-economically and culturally valuable species" (CDB 2010). Therefore, studies evaluating the consequences of species extinction risk to other biodiversity aspects, such as the diversity of economic uses or evolutionary history are essential for a more oriented conservation planning or conservation policies.

The IUCN Red List is an important tool for conservation actions, guiding several conservation decisions (Rodrigues et al. 2006; Vié et al. 2008). Nevertheless, Red List classification is a species-specific approach that comprises only demographic parameters of populations such as range area and population size (Brito et al. 2010) to rank species according to the likelihood of their extinction risk. Therefore, conservation actions based solely on Red Lists threat categories are usually focused in protecting species at greater risk of extinction and enable population recovery. To improve the effectiveness of biodiversity conservation actions it is necessary to incorporate the ecological, evolutionary and economical contributions made by each species (Loyola et al. 2009; CDB 2010; Flynn et al. 2011). For example, Hidasi-Neto et al. (2013) showed that Brazilian bird species classified in the IUCN threat categories have equal or less functional and phylogenetic diversity (PD) than expected by chance, highlighting that conservation actions based only on Red Lists are not enough to preserve ecological roles and evolutionary history. In this sense, it is valuable to investigate how much of other aspects of diversity are actually currently captured by Red Lists. Here, using the global IUCN Red List and two national Red Lists (Colombia and Madagascar) we answered the following questions: (1) What are the most frequent uses in palms? How are the most frequent uses distributed in threatened (vulnerable—VU, endangered—EN, critically endangered—CR) and non-threatened species (least concern—LC, and near threatened—NT)? (2) Do palm species included in the global IUCN Red List present higher plant use diversity (PUD) and PD than expected by chance?; (3) How does palm PD relate to palm threat level at global and national scale?; and (4) Are palm species with a higher number of uses and PUD also the most threatened? Considering these questions, we predict that: because only 21% of the total number of existing palm species are included in the IUCN Red List (most from Neotropics and Madagascar), palms listed in the IUCN Red List will have lower PUD and PD than expected by chance. Also, considering that palm species belonging to the same genus usually have similar uses (see Henderson et al. 1995) and that several uses attributed to palms are unsustainable, we predict that palms with higher PUD and that are closely related will be classified as having a high risk of extinction. Finally, given the negative effects of several uses attributed to palm species (e.g. death of the exploited plant due the extraction of palm heart for food, extraction of leaves and timber for construction), we expect that palms with a higher number of uses will be classified as being at the higher levels of threat, as a result of the intense exploitation faced by such species.

Materials and methods

Palms use diversity

We compiled data on palm uses from the literature (Henderson et al. 1995; Johnson 1996, 2010; Haynes and McLaughlin 2000; Kvist et al. 2001; Macía 2004; Ludwig 2006; Hourt 2008; Macía et al. 2011; Bernal et al. 2011; Martins et al. 2014; Gruca et al. 2014) and IUCN (IUCN 2015a) and PalmWeb (Palmweb 2015) websites. Every economic use was considered, no matter if it is a local (traditional) or large-scale use. All species with at least one type of use were included, totaling 939 palm species. Despite making a vast search on palm use the literature is skewed towards Neotropical palms, where ethnobotanical studies are more common (Henderson et al. 1995; Johnson 1996).

We verified species names and synonyms using Plantminer (Carvalho et al. 2010), with additional conference at The Plant List (The Plant List 2013), Tropicos (Missouri Botanical Garden 2015) and Kew (WCSP 2016, http://apps.kew.org/wcsp). We classified palm species in 15 categories of economic or traditional uses based on the Food and Agriculture Organization of the United Nations classification (Johnson 2010), with the following modifications: the categories “food” and “beverages” were merged in one category, as well as the categories “building materials” and “structure and shelter”; uses attributed to the category “palm oil” in Johnson (2010) were realocated, depending on its purpose, to the categories “fuel” or “food and beverages”; the category “fertilizer” was included in the category “chemical and industrial products”; “agricultural implements” and “weapons/hunting tools”, originally classified within “handicrafts”, were realocated to the new category “tools”; “clothing”, “furniture”, “games and toys”, “household items” and “jewellery”, also subcategories of “handicrafts”, became separated categories. Thus, species were assigned to at least one of the following categories: (1) food and beverages,

(2) feeds, (3) building materials, (4) medicine and rituals, (5) ornamental, (6) chemical and industrial products, (7) cosmetics and hygiene products, (8) fuel, (9) handicrafts, (10) tools, (11) clothing, (12) furniture, (13) games and toys, (14) household items, and (15) jewellery (Table S1).

Species threat level

We obtained information regarding species threat level using the global IUCN Red List version 2015.2 (www.iucnredlist.org). IUCN classification considers only species with sufficient data available that enables them to assign a threat level category for the species at a global scale. Consequently, from the 2550 species of palms considered by us in this study, only 540 are present in the IUCN Red List (Table S2). The majority of palms were classified by IUCN in 1998 and 2012 (229 and 192 species, respectively).

To evaluate if Red Lists are more likely to capture use and PD at narrower scales we also used the national Red Lists of Colombia (Galeano and Bernal 2005) and Madagascar (Rakotoarinivo et al. 2014). These and South Africa Red List are the most comprehensive national Red Lists for palms available to date. However, because South Africa has only six palm species (four LC, one VU and one EN; http://posa.sanbi.org) we did not include it in our study. After correcting for synonyms and excluding subspecies and varieties the Red List of Colombia ended up with 206 palm species (Table S2). The Red List from Madagascar has 192 species (Table S2). Only 35 species in the Colombian Red List are also classified in the IUCN list, from which 19 are in the same threat category in both lists. All palms classified in Madagascar Red List are also present in IUCN, with only three species classified in different categories.

Data analysis

We investigated how the most frequent uses are distributed in threatened (VU, EN, CR) and non-threatened species (LC and NT) using Chi square tests. Following an approach similar to Remans et al. (2011) we estimated palm PUD for all species included in the global IUCN Red List and for the species in each threat category for both national lists and the IUCN list (including DD and EW categories) using a functional diversity (FD) index (Petchey and Gaston 2002). FD measures the functional similarity among species considering their distances from each other in a functional dendrogram. For the IUCN Red List the functional dendrogram was based on a distance matrix comprising all palm species with at least one type of use (a total of 939 species; see Table S1). We created a distance matrix using the Jaccard distance with the *vegdist* function (R-package *vegan*, Oksanen et al. 2010) and the dendrogram using the UPGMA algorithm with function *hclust*. For Colombia Red List the 157 palm species that had at least one economic or traditional use were used to produce the functional dendrogram whereas for Madagascar only 67 species had uses in our database and, thus, were used to produce the dendrogram.

We calculated the observed and randomly expected PUD for all species included in the global IUCN Red List (285 species) and for the species within each threat level category (for the IUCN and the two national Red Lists) with at least one type of use in our database. Expected values were based on 999 randomizations where species were randomly selected from the respective species pool (all 939 species with at least one type of use in the case of the IUCN Red List, the 157 species with data on economic and traditional use from Colombia and the 67 species from Madagascar). With that we used the formula below to calculate the standardized effect size for each observed value of PUD, that is, how much of the observed PUD value departs from a random expectation

$$\frac{(\text{Observed PUD} - \text{average of random PUD values})}{\text{Standard deviation}}$$

where standard deviation is the respective standard deviation of the 999 randomized values. Negative values indicate that species have lower PUD than expected by chance, whereas positive values indicate higher PUD than expected by chance. We used the *ses.pd* function (R-package *picante*, Kembel et al. 2010).

In addition to PUD, we also quantified palms uses by calculating the mean number of uses within each threat category. We highlight, however, that PUD and the mean number of uses quantifies different aspects of palms uses. PUD takes into account the composition of uses, whereas the number of uses considers only how many uses are attributed to the species present in the same threat category. For example, a group formed by species with similar uses will have a low PUD, regardless of having a low or high mean number of uses. A group formed by species with different uses, in turn, will have a high PUD, also regardless of the number of uses attributed to its species.

Based on the most recent species-level phylogeny available for palms (Faurby et al. 2016) we calculated a maximum clade credibility tree (R-package *phangorn*, Schliep 2011) using 1000 trees based on Govaerts taxonomy (Govaerts et al. 2011). Eleven species in our database were absent in the phylogeny and were included as polytomies within their respective genus (package *phytools*, Revell 2012) in the maximum credibility tree. With the resulting phylogenetic tree we calculated the PD (PD, Faith 1992) for the entire global IUCN Red List (540 species) and for the species within each threat level category, including DD and EW. Randomly expected values of PD were calculated from 999 randomizations from the overall pool with all the species present in the phylogenetic tree (2550 species). We calculated standardized effects sizes following the same procedure described above to PUD. For the national Red Lists we followed the same procedure but pruning the phylogenetic tree for those species that were present in each national Red List (206 species for Colombia and 192 for Madagascar).

Using Spearman rank correlations we tested if a greater mean number of uses, higher PUD or higher PD were related to a greater threat level for palm species. Data Deficient and Extinct in the Wild categories were not included in the correlation analyses. To perform the correlations we transformed threat categories into an ordinal variable (LC = 1, NT = 2, VU = 3, EN = 4 and CR = 5). All analyses were performed in R R Development Core Team (2010).

Results

Considering the 939 palm species included in our database, the three most common uses are building material (46% of the species), food and beverages (45%), and ornamental (37%). These are also the three most common uses for the 285 species with reported uses included in the global IUCN Red List, but in that case 50% are ornamental, 49% used as food and beverages and 46% for building structures (Table S3). For the 157 palm species occurring in Colombia with known uses, 76% are used as building materials, 71% for food and 50% as household items. In Madagascar, on its turn, 55% of a total of 67 palms with reported uses are used for food and beverages, 51% as ornamentals and 48% for building materials (Table S3). When we compared the distribution of threatened and non-threatened species for the three most common uses in the global IUCN Red List there was an overrepresentation of ornamental species in the threatened categories (Table S4). However, when we considered the three most common palm uses in Colombia and Madagascar, there was no significant difference between threatened and non-threatened species (Table S4).

For the global IUCN Red List we found that all palm species listed and those within each threat level categories do not have more PUD than what would be expected by chance (Table 1). Moreover, species listed as DD, EN and CR have a lower diversity of uses than expected by chance (Table 1). In terms of evolutionary history all species listed by IUCN are more phylogenetically related than what one would expect by chance (Table 1). The same is true to DD and CR species (Table 1). Contrary to our predictions we found that, at global scale, the most threatened palms have few uses and a lower diversity of uses and evolutionary history (Figs. 1, 2). However, for the national Red Lists, Least Concern species had lower PUD and PD in Colombia whereas in Madagascar only Data Deficient species had lower PUD than expected by chance (Table 1). We did not find any relationship between threat status and PUD or PD for the national lists (Fig. 3). Concerning the number of uses, only in Madagascar there was also a negative correlation with threat status (Fig. 1).

Discussion

Achieving global goals of biodiversity conservation such as the Aichi Targets (CDB 2010, https://www.cbd.int/sp/targets/), requires the inclusion of multiple biodiversity facets in biodiversity assessments to complement conservations decisions. In that way, investigating how species loss will erode the evolutionary history and the use diversity of economically important species, such as palms, would improve conservation decisions and policies. Here, after evaluating all palm species included in the IUCN global Red List, we found that they represent a skewed sample that captures less use diversity and evolutionary history of the Arecaceae family than expected by chance. This is somewhat not surprising because only about 21% of palm species have been evaluated using IUCN Red List Categories and Criteria, and most of them are from the Neotropics and Madagascar. A similar pattern was found to the national Red Lists of Colombia and Madagascar. In this sense, conservation efforts solely based on threat status will not maximize the protection of palm evolutionary history nor the economic and traditional uses that they offer to mankind.

Palms are recognized by the IUCN as “essential to livelihoods worldwide and to the global economy” (IUCN 2015b). Considering such great importance we predicted that the higher the number of uses, the higher the risk of extinction a palm species would face. However, we found the opposite pattern, that is, less threatened palm species have more uses than those at higher risk of extinction. Considering that we used an artificial transformation, we highlight that the increased degree of threat between categories is not linear. Nevertheless, one explanation for our finding is that palms that are endangered or critically endangered have few specific uses that are unsustainable by nature—for example, *Dypsis albofarinosa*, a species widely exploited for ornamental purposes (Rakotoarinivo 2012). However, palm species listed in the global IUCN Red List share multiple uses irrespectively of their threat category. Thus, another potential explanation is that, on average, deforestation and habitat loss could be a much more important threat to many palm species (Rakotoarinivo et al. 2014). Nevertheless, given that the species listed on IUCN are a poor

Table 1 Palm plant use diversity (PUD) and phylogenetic diversity (PD) captured by IUCN and national Red Lists within each threat category

Category	Species	PUDobs	PUDrand	PUDz	*P*	Species	PDobs	PDrand	PDz	*P*
IUCN										
Entire list	285	23.679	26.645	−2.549*	0.005	540	6872.694	7550.102	−3.735*	0.001
DD	18	3.799	4.985	−2.124*	0.021	50	1307.614	1607.006	−2.653*	0.004
LC	84	12.905	13.330	−0.467	0.309	113	2832.840	2773.608	0.420	0.665
NT	34	7.930	7.680	0.350	0.627	55	1750.457	1738.658	0.103	0.558
VU	64	9.774	11.329	−1.819	0.032	119	2612.216	2877.597	−1.817	0.042
EN	44	6.541	9.051	−3.203*	0.004	96	2294.818	2510.392	−1.562	0.049
CR	39	5.893	8.331	−3.359*	0.001	105	1849.980	2656.654	−6.017*	0.001
Colombia										
DD	–	–	–	–	–	5	288.948	306.502	−0.314	0.394
LC	103	13.231	14.357	−2.010*	0.260	120	2129.574	2336.395	−2.629*	0.008
NT	30	6.508	6.460	0.092	0.543	42	1303.944	1292.039	0.129	0.536
VU	6	1.861	1.916	−0.199	0.405	16	729.315	680.611	0.5622	0.706
EN	13	4.004	3.546	1.220	0.899	17	709.389	745.482	−0.418	0.335
CR	4	0.961	1.361	−1.762	0.047	6	273.850	350.892	−1.284	0.108
Madagascar										
DD	3	0.492	1.070	−2.193*	0.037	13	174.789	278.703	−1.296	0.137
LC	11	2.469	2.755	−0.697	0.232	16	437.640	321.497	1.540	0.943
NT	5	2.072	1.608	1.424	0.931	14	279.058	296.113	−0.226	0.431
VU	19	4.311	3.682	1.369	0.913	43	593.913	577.865	0.208	0.587
EN	14	3.482	3.125	0.833	0.810	45	604.953	597.874	0.087	0.528

Table 1 continued

Category	Species	PUDobs	PUDrand	PUDz	*P*	Species	PDobs	PDrand	PDz	*P*
CR	15	2.793	3.241	−0.961	0.168	61	671.689	705.609	−0.407	0.328

IUCN Red List pool comprised, in the PUD analyses, all the 939 palm species from which potential uses are known; and all the 2550 palm species present in the phylogeny for the PD analyses. For the PUD analyses, national red lists pools comprised all the species present in their respective lists with at least one type of use (Colombia = 157 species; Madagascar = 67 species); and for the PD analyses, national red lists pools comprised all the palm species present in their respective lists (Colombia = 206 species; Madagascar = 192 species)

DD data deficient, *LC* least concern, *NT* near threatened, *VU* vulnerable, *EN* endangered, *CR* critically endangered, *PUDobs* observed plant use diversity, *PUDrand* mean expected PUD value obtained through 999 random samples from the pool, *PUDz* standardized effect size of PUD obtained by (PUDobs—PUDrand)/standard deviation of the 999 random values, *PDobs* observed phylogenetic diversity, *PDrand* mean phylogenetic diversity expected by chance obtained through 999 randomizations from the pool, *PDz* standardized effect size of PD obtained by (PDobs—PDrand)/standard deviation of the 999 random values

* Significant values

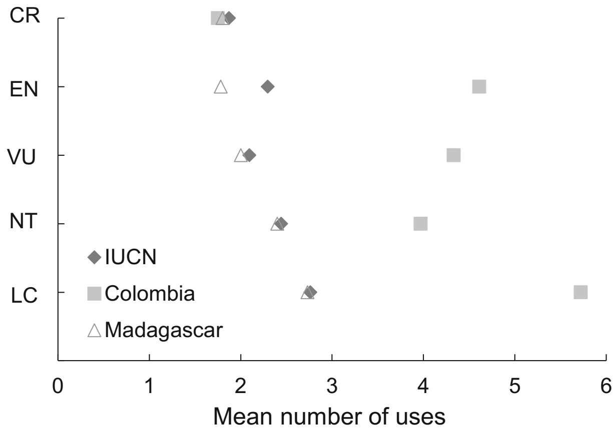

Fig. 1 Relationship between species mean number of uses and threat level in IUCN (Spearman's rs = −0.90; *P* = 0.037), Colombia (Spearman's rs = −0.60; *P* = 0.285) and Madagascar Red Lists (Spearman's rs = −0.90; *P* = 0.037). *LC* least concern, *NT* near threatened, *VU* vulnerable, *EN* endangered, *CR* critically endangered

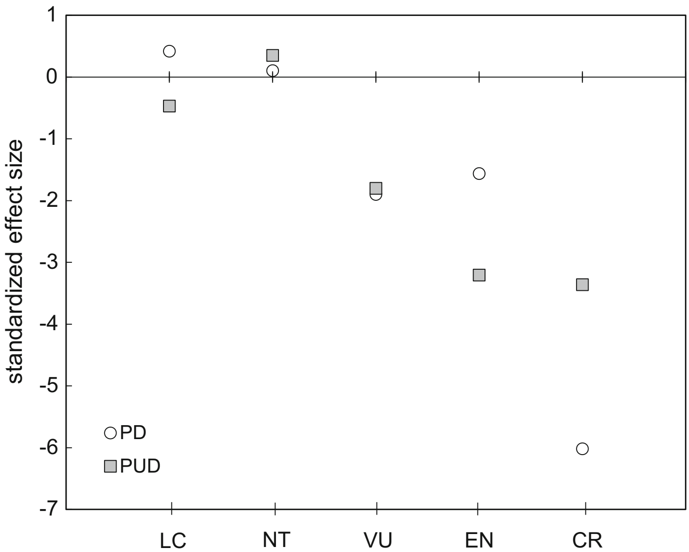

Fig. 2 Relationships between standardized effect size of phylogenetic diversity (PD) and IUCN threat level (Spearman's rs = −0.91; *P* = 0.017) and standardized effect size of plant use diversity (PUD) and IUCN threat level (Spearman's rs = −0.90; *P* = 0.016). *LC* least concern; *NT* near threatened, *VU* vulnerable, *EN* endangered, *CR* critically endangered

representation of palm biodiversity we are far from having a complete picture on the relative importance of contemporary threats to palm species. This will only be possible when a much great number of palm species were assessed at global and national scale.

We performed a systematic search on palms uses, resulting in a consistent database that includes around 36% of all palm species. The lack of records for such a great number of palms, however, does not mean that these species do not have any traditional or economic use. Instead, it indicates that when it comes to economic or traditional uses most of our natural resources are undocumented or underutilized (Gruca et al. 2016). There is a clear need for more ethnobotanical studies if we want to have a complete knowledge the use

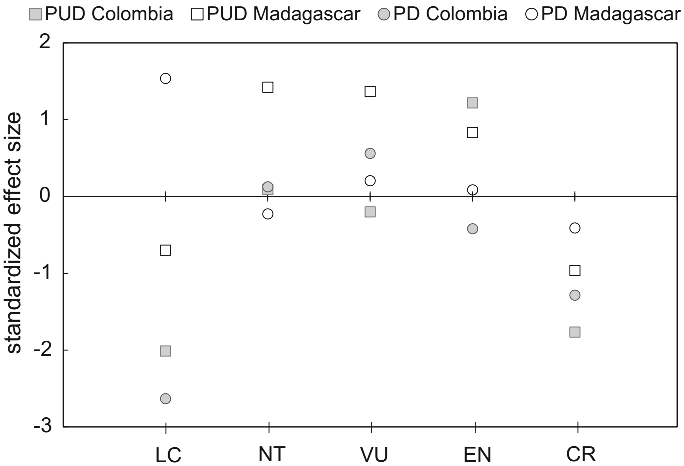

Fig. 3 Relationships between the standardized effect size of plant use diversity (PUD) and threat level (Colombia: Spearman's rs = 0.3; $P = 0.624$; Madagascar: Spearman's rs = −0.4; $P = 0.505$), and standardized effect size and phylogenetic diversity (PD) and threat level (Colombia: Spearman's rs = 0.1; $P = 0.873$; Madagascar: Spearman's rs = −0.7; $P = 0.188$) of palm species classified on national Red List. *LC* least concern, *NT* near threatened, *VU* vulnerable, *EN* endangered, *CR* critically endangered

diversity for palm species. Nevertheless, we did not find any record of use for almost half of palm species classified in the IUCN Red List (255 species). Given the poor coverage of IUCN Red List on palm diversity there is a need to focus future assessments on those 650 species that have known uses but are not covered yet by IUCN.

Whereas some advocate that we are facing the sixth great extinction event (Barnosky et al. 2011) it is also likely that we are also facing the risk of losing economical and sustainable opportunities for our maintenance and survival as a species. Human populations worldwide explore many palm species as a source of food, to obtain raw material for construction, to extract important chemical products (e.g. fertilizers and wax), as medicines and even for minor purposes such as the production of handicrafts and household items (see Table S1). This reflects the great economic and cultural reliance of human populations on natural resources (Hanazaki et al. 2000; Haynes and McLaughlin 2000; Macía 2004; Johnson 2010; Macía et al. 2011; Brashares et al. 2011; Gruca et al. 2014, 2016). Even if palm species are widely used as source of food and building materials (uses that may also represent a threat to palms populations; Muler et al. 2014; Vallejo et al. 2014), such uses are more common at local scales (Bernal et al. 2011) or by traditional populations. On the other hand, the trade in palms with ornamental potential is worth a lot of money in national and international markets. The high number of threatened species in the IUCN Red List used for ornamental purposes may reflect the commonly unsustainable practices related to this use. For example, seed collection and seedling removal of native palms for ornamental palm market have negative effects in the regeneration of palm populations (Johnson 2010). However, despite the fact that a large proportion of palms classified in IUCN Red List are used for ornamental purposes (142 species out of 285 in total), only 10 species (three Vulnerable, five endangered, and two critically endangered) are present in the convention on international trade of endangered species (CITES), an initiative to ensure the non-threaten trade of wildlife (http://checklist.cites.org). Our findings just emphasizes the urgent need to improve conservation actions regarding such species (Johnson 1996), as well as expanding the number of palms included in CITES and IUCN Red lists.

Even if with similar number of species in their Red Lists, Colombia and Madagascar differ greatly regarding the number of palms with uses (157 and 67, respectively). The high palm diversity in the Americas and, more specifically in the Amazon region, has attracted researches for decades (Kahn 1988; Henderson et al. 1995; Muñiz-Miret et al. 1996). Many studies are concentrated in Colombia (Johnson 1996), indicating a potential geographical bias on the knowledge of palm uses. Studies in Madagascar, in turn, are scarce and popular knowledge is thought to be underestimated (Gruca et al. 2016). Also, differences in regional ethnobotanical studies may be responsible for the difference in the number and variety of uses detected between Colombian and Madagascar palms. Nevertheless, many palms of Madagascar are at higher risk of extinction, and future predictions suggest increasing threats for palm species (Rakotoarinivo et al. 2014; Blach-Overgaard et al. 2015). Therefore, more ethnobotanical studies in Madagascar are imperative to answer if Madagascar palms have few uses or if their uses are undocumented (Gruca et al. 2016).

Recommendations

Since the 1960s, the IUCN has published lists and books informing about the threat level of several species (Vié et al. 2008), acting as a guiding tool for conservation actions. Nevertheless, despite several advances on species categorization (Rodrigues et al. 2006), the IUCN Red List Categories and Criteria do not take into account other facets of diversity such as functional or PD (Hidasi-Neto et al. 2015) nor the uses that species may have to mankind. We recognize that the focus of IUCN Red List is on identifying species at greater risk of extinction based on demographic variables, irrespective of how much such species will contribute to the maintenance other types of diversity rather species richness. Furthermore, including species in the IUCN Red List depends upon efforts of species specialist groups, what usually results in a non-random list of species in taxonomic terms.

Nevertheless, advances on the ecological field highlight that biodiversity estimates must comprise more than just taxonomical units (Flynn et al. 2011; Rolland et al. 2012; Hidasi-Neto et al. 2012). In addition to the traditional species richness, other aspects have been considered as important or even more relevant when the aim is to conserve biodiversity under the current scenario of climate change (Díaz and Cabido 2001; Hidasi-Neto et al. 2013, 2015), and improve the success of conservation actions through the maintenance of ecosystem functions and services (Rolland et al. 2012). In this sense, conservation decisions based solely on species threat level may be inefficient for conserving other diversity aspects (Davies et al. 2011; Hidasi-Neto et al. 2015). The high levels of extinction risk faced by palm species (Rakotoarinivo et al. 2014) associated with the predicted future negative effects of climate change (Blach-Overgaard et al. 2015), highlight the urgent need to expand the number of palm species present in the global IUCN Red List to broaden the coverage of the plant use diversity and evolutionary history to this plant family. Considering that a high proportion of palms still need to be included in national and global Red Lists, a first step should be towards compiling data on palms with known uses to encourage and facilitate their inclusion in Red Lists. The elaboration of national Red Lists of palms should also be another priority because conservation actions are taken at national scale. Additionally, conservation decisions could be improved if taking into account other diversity aspects of biodiversity. EcoEDGE (Hidasi-Neto et al. 2015), a new approach that identifies the ecological and evolutionary distinctiveness of endangered species, may represent such step. It allows one to rank species according to their not only according to their threat status but also to their unique contribution given a set of traits or its evolutionary information. EcoEDGE could help identifying areas where palms present distinct uses or evolutionary history and weight that by the species extinction risk (see Fig. S2 in Hidasi-Neto et al. 2015) to maximize such diversity aspects in conservation decisions. We need to move beyond ranking species only by their extinction risk. Instead, we need to answer what consequences would be if we lose this or that species and use it to guide conservation decisions.

Acknowledgements LMOL is grateful to Coordenação de Aperfeiçoamento de Pessoal de Nível Superior for the scholarship granted. MVC has a productivity Grant from Conselho Nacional de Desenvolvimento Científico e Tecnológico (#306843/2012-9, #307796/2015-9).

Compliance with ethical standards

Conflict of interest The authors declare they have no conflict of interest.

References

Balick M (1988) The palm-tree of life: biology, utilization and conservation. The New York Botanical Garden, New York
Barnosky AD, Matzke N, Tomiya S et al (2011) Has the Earth's sixth mass extinction already arrived? Nature 471:51–57. doi:10.1038/nature09678
Bernal R, Torres C, García N et al (2011) Palm management in South America. Bot Rev 77:607–646. doi:10.1007/s12229-011-9088-6
Blach-Overgaard A, Balslev H, Dransfield J et al (2015) Global-change vulnerability of a key plant resource, the African palms. Sci Rep 5:1–10. doi:10.1038/srep12611
Brashares JS, Golden CD, Weinbaum KZ et al (2011) Economic and geographic drivers of wildlife consumption in rural Africa. Proc Natl Acad Sci USA 108:13931–13936. doi:10.1073/pnas.1011526108
Brito D, Ambal RG, Brooks T et al (2010) How similar are national red lists and the IUCN Red List? Biol Conserv 143:1154–1158. doi:10.1016/j.biocon.2010.02.015
Byg A, Balslev H (2001) Diversity and use of palms in Zahamena, eastern Madagascar. Biodivers Conserv 10:951–970
Cardinale BJ, Duffy JE, Gonzalez A et al (2012) Biodiversity loss and its impact on humanity. Nature 486:59–67. doi:10.1038/nature11148
Carvalho GH, Cianciaruso MV, Batalha MA (2010) Plantminer: a web tool for checking and gathering plant species taxonomic information. Environ Model Softw 25:815–816. doi:10.1016/j.envsoft.2009.11.014
CDB (2010) Strategic plan for biodiversity 2011–2020
Chen H, Qian H, Spyreas G, Crossland M (2010) Native-exotic species richness relationships across spatial scales and biotic homogenization in wetland plant communities of Illinois, USA. Divers Distrib 16:737–743. doi:10.1111/j.1472-4642.2010.00679.x
Clavel J, Julliard R, Devictor V (2011) Worldwide decline of specialist species: toward a global functional homogenization? Front Ecol Environ 9:222–228. doi:10.1890/080216
Davies TJ, Smith GF, Bellstedt DU et al (2011) Extinction risk and diversification are linked in a plant biodiversity hotspot. PLoS Biol 9:e1000620. doi:10.1371/journal.pbio.1000620
de la Torre L, Calvo-Irabién LM, Salazar C et al (2009) Contrasting palm species and use diversity in the Yucatan Peninsula and the Ecuadorian Amazon. Biodivers Conserv 18:2837–2853. doi:10.1007/s10531-009-9610-x
Díaz S, Cabido M (2001) Vive la différence: plant functional diversity matters to ecosystem processes. Trends Ecol Evol 16:646–655
Dransfield J, Beentje H (1995) The palms of Madagascar. Royal Botanic Gardens, Kew and the Palm International Society, Lawrence
Dransfield J, Uhl NW, Asmussen CB et al (2008) Genera Palmarum: the evolution and classification of palms. Kew Publishing
Faith DP (1992) Conservation evaluation and phylogenetic diversity. Biol Conserv 61:1–10. doi:10.1016/0006-3207(92)91201-3

Faurby S, Eiserhardt WL, Baker WJ, Svenning J-C (2016) An all-evidence species-level supertree for the palms (Arecaceae). Mol Phylogenet Evol 100:57–69. doi:10.1016/j.ympev.2016.03.002
Flynn DFB, Mirotchnick N, Jain M et al (2011) Functional and phylogenetic diversity as predictors of biodiversity-ecosystem-function relationships. Ecology 92:1573–1581
Galeano G, Bernal R (2005) Palmas. In: Calderon E, Galeano G, García N (eds) Libr. Rojo Plantas Colomb. Vol. II Palmas, frailejones y zamias. Instituto Alexander von Humboldt, Instituto de Ciencias Naturales-Universidad Nacional de Colombia, Ministerio del Medio Ambiente, Bogotá, Colombia, pp 59–224
Govaerts R, Dransfield J (2005) World checklist of palms. Royal Botanic Gardens, Kew
Govaerts R, Dransfield J, Zona SF et al (2011) World checklist of Arecaceae facilitated by the Royal Botanic Gardens, Kew. http://apps.kew.org/wcsp/. Accessed 1 Jan 2016
Gruca M, van Andel TR, Balslev H (2014) Ritual uses of palms in traditional medicine in sub-Saharan Africa: a review. J Ethnobiol Ethnomed 10:60. doi:10.1186/1746-4269-10-60
Gruca M, Blach-Overgaard A, Dransfield J, Balslev H (2016) Medicinal palms (Arecaceae) in Madagascar—undocumented or underutilized? Bot J Linn Soc 182:517–525
Hanazaki N, Tamashiro JY, Leitão-Filho HF, Begossi A (2000) Diversity of plant uses in two Caiçara communities from the Atlantic Forest coast, Brazil. Biodivers Conserv 9:597–615
Hansen MC, Stehman SV, Potapov PV (2010) Quantification of global gross forest cover loss. Proc Natl Acad Sci USA 107:8650–8655. doi:10.1073/pnas.0912668107
Haynes J, McLaughlin J (2000) Edible palms and their uses. University of Florida—Institute of Food and Agricultural Sciences, Homestead
Henderson A, Galeano G, Bernal R (1995) Field guide to the palms of the Americas. Princeton University Press, Princeton
Hidasi-Neto J, Barlow J, Cianciaruso MV (2012) Bird functional diversity and wildfires in the Amazon: the role of forest structure. Anim Conserv 15:407–415. doi:10.1111/j.1469-1795.2012.00528.x
Hidasi-Neto J, Loyola R, Cianciaruso MV (2013) Conservation actions based on red lists do not capture the functional and phylogenetic diversity of birds in brazil. PLoS ONE 8:e73431. doi:10.1371/journal.pone.0073431
Hidasi-Neto J, Loyola R, Cianciaruso MV (2015) Global and local evolutionary and ecological distinctiveness of terrestrial mammals: identifying priorities across scales. Divers Distrib 21:548–559. doi:10.1111/ddi.12320
Hourt KE (2008) A field guide of the rattans of Cambodia. WWF Greater Mekong—Cambodia Country Programme, Phnom Penh
IUCN (2015) The IUCN Red List of Threatened Species. Version 2015.2. www.iucnredlist.org
IUCN (2015) International Union for Conservation of Nature. http://cms.iucn.org/about/work/programmes/species/our_work/plants/plants_projects_initiatives/plants_for_people_/. Accessed 20 May 2007
Johnson D (1996) Palms: their conservation and sustained utilization. Status Survey and Conservation Action Plan. IUCN/SSC Palm Specialist Group, Gland
Johnson DV (2010) Tropical palms—2010 revision. Food and Agriculture Organization of the United Nations, Rome
Kahn F (1988) Ecology of economically important palms in Peruvian Amazonia. Adv Econ Bot 6:42–49
Kembel SW, Cowan P, Helmus M et al (2010) Picante: r tools for integrating phylogenies and ecology. Bioinformatics 26:1463–1464
Kvist LP, Andersen MK, Stagegaard J et al (2001) Extraction from woody forest plants in flood plain communities in Amazonian Peru: use, choice, evaluation and conservation status of resources. For Ecol Manag 150:147–174
Loyola RD, Oliveira-Santos LGR, Almeida-Neto M et al (2009) Integrating economic costs and biological traits into global conservation priorities for carnivores. PLoS ONE 4:e6807. doi:10.1371/journal.pone.0006807
Ludwig N (2006) Acanthophoenix in Réunion, Mascarene Islands. Palms 50:82–98
Macía MJ (2004) Multiplicity in palm uses by the Huaorani of Amazonian. Bot J Linn Soc 144:149–159
Macía MJ, Armesilla PJ, Cámara-Leret R et al (2011) Palm uses in Northwestern South America: a quantitative review. Bot Rev 77:462–570. doi:10.1007/s12229-011-9086-8
Martins RC, Filgueiras TDS, Albuquerque UP (2014) Use and diversity of palm (Arecaceae) resources in Central Western Brazil. Sci World J 2014:942043. doi:10.1155/2014/942043
Mckinney ML, Lockwood JL (1999) Biotic homogenization: a few winners replacing many losers in the next mass extinction. Trends Ecol Evol 14:450–453
Muler AE, Rother DC, Brancalion PS et al (2014) Can overharvesting of a non-timber-forest-product change the regeneration dynamics of a tropical rainforest? The case study of *Euterpe edulis*. For Ecol Manag 324:117–125. doi:10.1016/j.foreco.2013.09.001

Muñiz-Miret N, Vamos R, Hiraoka M et al (1996) The economic value of managing the açaí palm (*Euterpe oleracea* Mart.) in the floodplains of the Amazon estuary, Pará, Brazil. For Ecol Manag 87:163–173. doi:10.1016/S0378-1127(96)03825-X

Oksanen J, Blanchet FG, Kindt R et al (2010) Vegan: community ecology package. R package version 1.17-4

Missouri Botanical Garden Tropicos.org (2015). http://www.tropicos.org. Accessed 1 Jan 2015

Palmweb (2015) Palmweb: palms of the world online. http://palmweb.org/. Accessed 15 May 2015

Petchey OL, Gaston KJ (2002) Functional diversity (FD), species richness and community composition. Ecol Lett 5:402–411

R Development Core Team (2010) R: a language and environment for statistical computing

Rakotoarinivo M (2012) *Dypsis albofarinosa*. In: IUCN Red List Threat. Species. http://dx.doi.org/10.2305/IUCN.UK.2012.RLTS.T17060715A17060724.en. Accessed 13 Dec 2016

Rakotoarinivo M, Dransfield J, Bachman SP et al (2014) Comprehensive Red List assessment reveals exceptionally high extinction risk to Madagascar palms. PLoS ONE 9:e103684. doi:10.1371/journal.pone.0103684

Remans R, Flynn DFB, DeClerck F et al (2011) Assessing nutritional diversity of cropping systems in African villages. PLoS ONE 6:e21235. doi:10.1371/journal.pone.0021235

Revell LJ (2012) Phytools: phylogenetic tools for comparative biology (and other things). Methods Ecol Evol 3:217–223. doi:10.1111/j.2041-210X.2011.00169.x

Rodrigues ASL, Pilgrim JD, Lamoreux JF et al (2006) The value of the IUCN Red List for conservation. Trends Ecol Evol 21:71–76. doi:10.1016/j.tree.2005.10.010

Rolland J, Cadotte MW, Davies J et al (2012) Using phylogenies in conservation: new perspectives. Biol Lett 8:692–694. doi:10.1098/rsbl.2011.1024

Salm R, Jalles-Filho E, Schuck-Paim C (2005) A model for the importance of large arborescent palms in the dynamics of seasonally-dry amazonian forests. Biota Neotrop 5:1–6. doi:10.1590/S1676-06032005000300011

Schliep KP (2011) Phangorn: phylogenetic analysis in R. Bioinformatics 27:592–593

Sosnowska J, Balslev H (2009) American palm ethnomedicine: a meta-analysis. J Ethnobiol Ethnomed 5:43. doi:10.1186/1746-4269-5-43

The Plant List (2013) The plant list (version 1.1.). http://www.theplantlist.org/. Accessed 20 Jun 2015

Vallejo MI, Galeano G, Bernal R, Zuidema PA (2014) The fate of populations of Euterpe oleracea harvested for palm heart in Colombia. For Ecol Manag 318:274–284. doi:10.1016/j.foreco.2014.01.028

Vié J, Hilton-Taylor C, Pollock C et al (2008) The IUCN Red List: a key conservation tool. 2008 review. IUCN Red List Threatened Species

WCSP (2016) World checklist of selected plant families. Facilitated by the Royal Botanic Gardens, Kew. http://apps.kew.org/wcsp. Accessed 23 Jan 2016