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Diversity and use of palms in Zahamena, eastern Madagascar

A. BYG* and H. BALSLEV
*Department of Systematic Botany, Institute of Biology, University of Aarhus, Nordlandsvej 68, DK-8240 Risskov, Denmark; *Author for correspondence (fax: +45-86139326)*

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Abstract. Madagascar's palm flora is very diverse (171 species) and has a high degree of endemism (97%). Palm products make an important contribution to the household economy of many rural families, especially in the palm-rich eastern escarpments. Many palms are, however, threatened by overexploitation and habitat destruction. We investigated which palm species were found and used in three villages on the eastern escarpments of Madagascar. The importance local people accorded to each species was compared to the number of its uses, number of people using it, and other aspects of its use. From this comparison it was concluded that even if important palms are used for more purposes than less important palms, they owe their importance to one or two of their main uses. We also investigated if there were any patterns in the distribution of informants' knowledge and whether such patterns could be related to socio-economic factors. There was a positive relationship between knowledge about palms and personal wealth and a negative relationship between distance to the forest and amount of knowledge. The latter can be a sign of an ongoing knowledge erosion. Sustainable use of native palms should be encouraged as it may contribute positively to village economy and knowledge preservation, and may provide incentives for preservation of remaining forest tracts.

Key words: ethnobotany, indigenous knowledge patterns, Madagascar, palms, plant importance, quantitative methods

Introduction

Madagascar is one of the world's seven biodiversity hotspots and its flora and fauna are characterised by extremely high levels of endemism (IUCN 1991). This also holds true for the Malagasy palm flora with 171 species of which 97% are endemic to the island (Dransfield and Beentje 1995). In Madagascar as elsewhere, palms are used for a large number of applications, which make them an important resource, but which may also endanger them. Especially for subsistence farmers living in the palm-rich eastern escarpments of Madagascar palms provide important supplements to farm products. Many of the palms have a limited distribution and are only found in primary forests, which makes them vulnerable to threats from overexploitation and habitat destruction. The majority of palms in Madagascar (116 species) are thus classified as vulnerable, endangered or even critical while information is uncertain or lacking for many other species (Dransfield and Beentje 1995).

If the current threat to Malagasy palms is to be alleviated it is necessary to gain a better understanding not only of the ecology of the palms, but also of the particular needs of local people and of their patterns of plant utilisation. In particular, it will be necessary to know which groups in society are most dependent on natural resources such as palms, which products are mainly extracted and what are the characteristics that make certain plant species more important than others.

A study of local diversity and use of palms was conducted in three Betsimisaraka villages to answer some of these questions. The ethnic group of the Betsimisaraka inhabits a large part of the eastern escarpments of Madagascar, where the last remnants of primary forests are situated. The study focused on three different aspects of their palm use. Firstly, the diversity of palm species found and used in the area and the relative contribution of each species to the daily lives of the members of the communities were investigated, and current and historical uses were recorded.

Secondly, the relative importance of different palm species was compared on the basis of local people's notions of their importance. Concepts of importance are of scientific interest, because they are an integrated part of cultural value systems, but they are also of significance to practitioners of conservation biology. It seems plausible that people will be more motivated to conserve and find sustainable ways of exploitation for species they regard as important compared to species they find less important. On the other hand, if less important species are also used less or the derived products are of minor importance, it may be relatively easy to change usage patterns for these species. Therefore, species' importance was compared to different aspects of their use, such as number of uses, number of people using them, and the degree of consensus among informants regarding the uses of a palm. From the comparison conclusions were drawn concerning the reasons for considering certain species important.

Thirdly, it was investigated whether there were any discernible patterns in informants' knowledge. Patterns in informants' knowledge can indicate whether knowledge is shared among all members of a community or whether it is specialist property or gradually accumulated throughout life. Specialist knowledge or gradually accumulated knowledge is usually at higher risk of being lost than commonly shared knowledge when a community is facing environmental or social changes (Phillips and Gentry 1993b). At the same time, distribution patterns of knowledge in a society can also indicate ongoing changes. Social changes leading to new ways of life or environmental changes leading to the abandonment of exploitation of certain plant resources, will often create patterns in knowledge distribution, where only the oldest community members or members with certain socio-economic characteristics still retain the knowledge. Therefore, it was investigated whether there was any relationship between palm knowledge and informants' socio-economic circumstances. Such relationships are of practical importance with regard to nature conservation, as they can indicate which groups in society are most dependent on natural resources and what mechanisms drive resource exploitation.

Study area

The study took place in the vicinity of the Zahamena protected areas in the eastern escarpments of Madagascar (Figure 1), located approximately 50 km inland and covering an area of about 640 km^2. Altitudes range from 200 to 1500 m above sea level. Humidity is generally high throughout the year (1500–2000 mm rain annually), though lessening to the west, and temperatures are moderate (monthly means ranging from 15–24 °C). The vegetation consists of rainforest in the east, changing to humid forest to semi-humid forest in the western parts of the protected areas. The core protected areas consist of two national park lots and one parcel of strict nature reserve that are surrounded by buffer zones where controlled extraction of some forest products takes place. Outside the protected areas and buffer zones primary forest is virtually non-existent in the area.

Voucher specimens were collected at two different sites in the study area: Vatovelona forest (17°40′ S, 49°00′ E, 550–700 m above sea level) at the boundary of the Zahamena Strict Nature Reserve and its surrounding buffer zone, and at Ambinany Namantoana forest (17°39′ S, 48°57′ E, 600–800 m above sea level) at the border of the Zahamena Strict Nature Reserve, Zahamena National Park parcel no. 2 and the buffer zone (Figure 1).

The three villages encompassed in the study are located at 500–700 m altitude above sea level and are only accessible by foot, 1–2 days from the nearest road, and 0.5–3 h from the forest (Figure 1). The villages were chosen so as to differ with regard to size, proximity to the protected areas and period of establishment. Village no. 1 (Manakambahinty I) is the largest of the three and is situated in medium distance from the protected areas. This village is the economic centre of the area and is characterised by a considerable social stratification. Village no. 2 (Mahasoa) is a medium-sized village and is situated furthest from the forest. Village no. 3 (Ambatoharanana) is the smallest, most recent, and most homogenous of the three villages and it is located in immediate proximity to the protected areas.

Materials and methods

The study is based on an oral survey comprising 54 local residents from three villages in the Zahamena area. The survey consisted of open-ended questions concerning which palm species people use for different purposes. Informants were also asked which palm species they regard as most important and if they knew any palm products that were not being used any more. Answers were converted into a standardised form and counted. Statistical analyses of the interview data were performed to detect differences between palm species and differences between informants. Additional information about palm uses was obtained in the field from key informants renowned for their good command of forest lore.

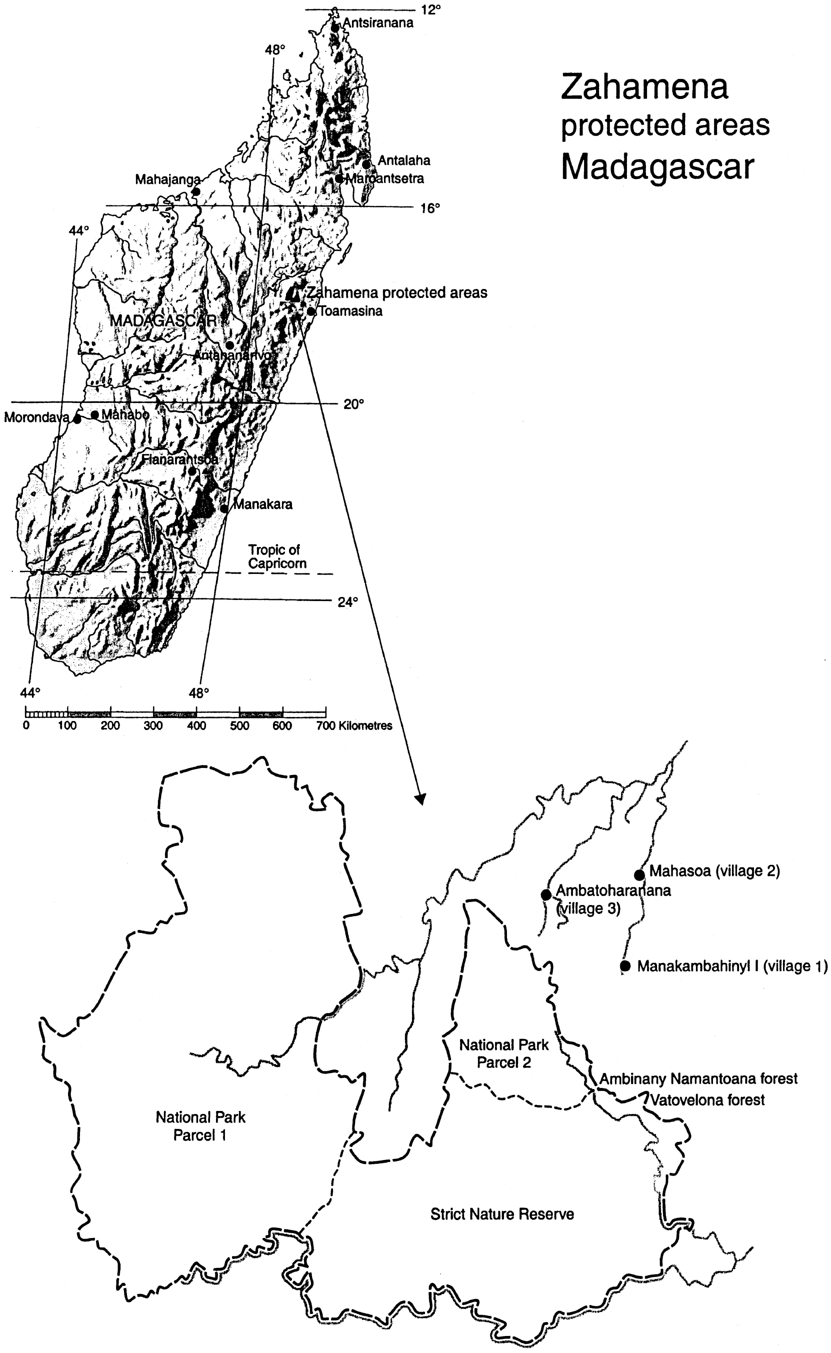

Figure 1. Map showing location of the Zahamena protected areas in eastern Madagascar, location of the three villages where interviews were conducted and forests where collection of voucher specimens took place.

Voucher specimens are deposited at the herbaria of the Parc Botanique et Zoologique de Tsimbazaza, Madagascar, Royal Botanic Gardens of Kew (K), UK, and Aarhus University (AAU), Denmark. Species distinguished in the analyses are 'folk species,' i.e., plant groups delimited as separate species by local residents.

Total species diversity (SD_{tot}) and total species equitability (SE_{tot}) values were calculated in order to obtain a measure of how diversified the use of palms among the Betsimisaraka is and how evenly different palm species contribute to their livelihood (Table 1).

Different measures of palm use and importance were calculated for all species encountered in the course of the survey (Table 2). The different measures of palm use and importance were statistically tested for possible correlations with each other and with the number of different types of uses a species was reported to have by means of Spearman's and Kendall's non-parametrical tests. A Shapiro–Wilk test was performed to test whether informants' knowledge, measured as number of uses and number of species mentioned by each informant, could be regarded as a sample of a normally distributed population. In addition, different measures of the informants' knowledge of palm uses were calculated and regressed onto socio-economic variables (Table 3).

Stepwise linear regression was used to relate different measures of informants' palm knowledge to socio-economic variables (Table 7). Some of the explanatory and dependent variables were transformed in order to achieve values of skewness and kurtosis ≤ 1.0 (Table 7). A more detailed description of the employed variables has been provided in our upcoming paper on *Dypsis fibrosa*. The employed transformations justify use of linear regression despite violations of the assumption that data follow a multivariate normal distribution. It was only in the case of the category 'number

Table 1. Measures of palm use, which were calculated to determine how many palm species were used and how evenly different palm species contributed to the total use of palms in three Betsimisaraka villages in eastern Madagascar.

Measure	Calculation	Description
Total species diversity (SD_{tot})	$SD_{tot} = 1/\Sigma P_s^2$; P_s = contribution of species s to the total use of palms in the study communities (= number of times species s was mentioned divided by the total number of reports of palm uses)	Measures how many species are used and how evenly they contribute to total palm use. Values range between 0 and n
Total species equitability (SE_{tot})	$SE_{tot} = SD_{tot}/n$; n = number of species used	Measures how evenly different palm species contribute to total palm use, independently of the number of species used. Values range between 0 and 1

Table 2. Measures of importance and use of palm species calculated to determine which aspects of palm use contribute to the importance accorded to palms by local people in eastern Madagascar. UV_s is modified from Phillips and Gentry (1993a).

Measure	Calculation	Description
Importance value (IV_s)	$IV_s = n_{is}/n$; n_{is} = number of informants who consider species s most important. n = total number of informants	Measures the proportion of informants who regard a species as most important. Values range between 0 and 1
Use value (UV_s)	$UV_s = \Sigma UV_{is}/n$; UV_{is} = number of uses informant i knows for species s	Measures the average number of uses informants know for a species
Use diversity value (UD_s)	$UD_s = 1/\Sigma P_c^2$; P_c = contribution of use category c to the total utility of a species s (=number of times species s was mentioned within each use category, divided by the total number of reports of use of species s across all use categories)	Measures for how many use categories a species is used and how evenly these contribute to its total use. Values range between 0 and number of use categories for which it is used
Use equitability value (UE_s)	$UE_s = UD_s/UD_{s\,max}$; $UD_{s\,max}$ = maximum possible use diversity value for a species s with uses occurring in a given number of categories	Measures how evenly the different uses contribute to the total use of a species independent of the number of use categories. values range between 0 and 1
Informant diversity value (ID_s)	$ID_s = 1/\Sigma P_i^2$; P_i = contribution of informant i to the total knowledge pool of species s (number of reports of use of species s by informant i divided by the total number of reports of use of species s)	Measures how many informants use a species and how its use is distributed among them. Values range between 0 and the number of informants using it
Informant equitability value (IE_s)	$IE_s = ID_s/ID_{s\,max}$; $ID_{s\,max}$ = maximum informant diversity value for a species s which is known by a given number of informants	Measures how the use of a species is distributed among informants independently of the number of informants using it. Values range between 0 and 1
Use consensus value (UC_s)	$UC_s = 2n_s/n - 1$; n_s = number of people using a species s	Measures how large the degree of accordance is between informants concerning whether they regard a species as useful or not. Values range between −1 and +1
Purpose consensus value (PC_s)	$PC_s = \Sigma P_u^2/S$; P_u = proportional contribution of use u to the total utility of a species s (= number of times use u was reported for species s divided by the total number of reports of use of species s). S = number of types of uses of species s	Measures how large the degree of accordance is among informants using it concerning what purposes they use it for. Values range between 0 and 1

Table 3. Measures of informants' palm knowledge calculated to investigate how homogenous knowledge was distributed in three Betsimisaraka villages in eastern Madagascar and whether knowledge differences were related to socio-economic factors.

Measure	Calculation	Description
Relative use value (RUV_i)	$RUV_i = [(\Sigma UV_{is}/UV_s)]/n$; UV_{is} = number of uses that informant i knows for species s, UV_s = use value of species s (= average number of uses that informants know for species s), n = number of useful species	Measures how many palm uses an informant knows relative to the average knowledge among all informants (Phillips and Gentry 1993a)
Species diversity value (SD_i)	$SD_i = 1/\Sigma P_s^2$; P_s = contribution of a species s to informant i's total use of palms (=number of times species s was mentioned by informant i divided by the total number of informant i's answers)	Measures how many species an informant uses and how evenly his uses are distributed among the species. Values range between 0 and the number of species used by the informant
Species equitability value (SE_i)	$SE_i = SD_i/SD_{i\,max}$; $SD_{i\,max}$ = maximum possible species diversity value for an informant i who uses a given number of species	Measures how evenly an informant makes use of the palms he knows, independently of the number of palms used. Values range between 0 and 1

of species used for rituals' that it was not possible to reduce skewness and kurtosis sufficiently. Therefore, answers concerning ritual use of palms were modelled as a binary ordinal variable (with the two types of answers: 'uses palms' and 'does not use palms') and logistic regression was employed in a stepwise forward selection procedure to investigate whether there was any significant relation between untransformed socio-economic variables and the use of palms for rituals.

Results and discussion

Palm diversity

Altogether, 30 different folk species, i.e., plant groups viewed as distinct species by local residents, occurred in our study area (Appendix). A total of 26 folk species were encountered in the field, while four additional folk species were reported during interviews. In three cases separate folk species were the same scientific species as other folk species reducing the number of scientific species to 23. A number of five folk species found in the area were not reported as useful during interviews, even though key informants had identified them as useful species in the field. During the interviews 774 reports of palm uses covering 25 folk species were gathered (Appendix). The most frequently mentioned application was that of palm hearts as food source (Figure 2). Of the 774 reports 78 were of products which were not being used any more (Figure 3). Informants mainly cited the advent of modern products (e.g., shotguns, cotton cloth, plastic bags) and the decline of palms and primary forest as reasons why these products were not being used any more.

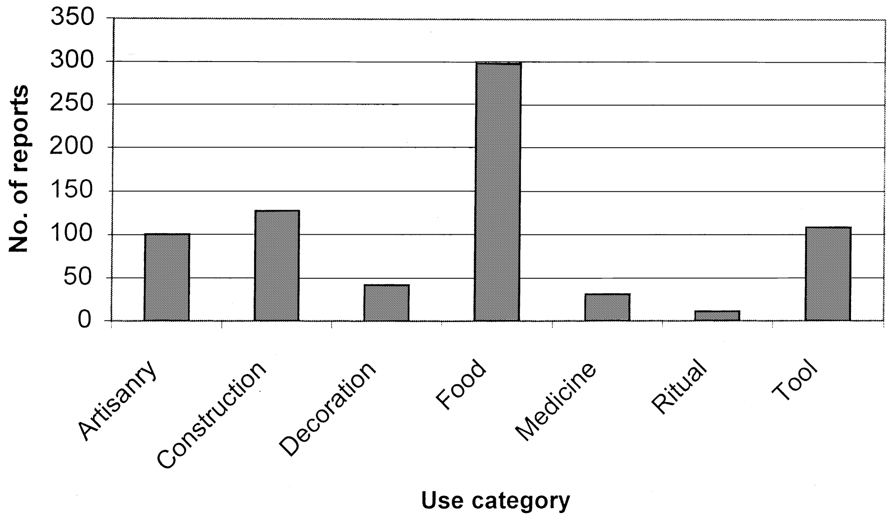

Figure 2. Number of reports of different categories of palm uses in eastern Madagascar.

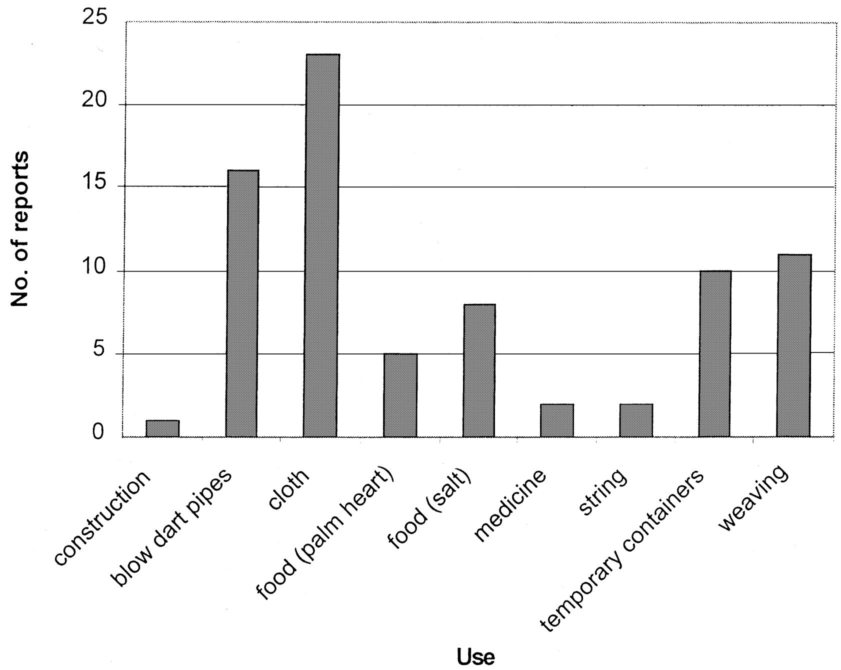

Figure 3. Number of reports of different kinds of palm products which are not being used any more.

Total species diversity (SD_{tot}) for the overall use of palms in the study communities was calculated to be $SD_{tot} = 13.4$ while the corresponding species equitability value was $SE_{tot} = 0.45$. These values indicate that palm use is not homogenous in the studied communities. Many of the species were mentioned only by a few people. Considering the relative small sample size of informants and the small fraction of the protected areas where palms were collected, further inquiries and collecting trips would probably lead to records of even more species and uses. Of 23 encountered scientific species four are classified as endangered, while seven are classified as vulnerable, and two are classified as rare (Appendix). Only seven species can be regarded as common and of these three are cultivated.

Despite the impressive number of reports of palm uses it cannot be concluded that palms provide a larger contribution to local peoples lives than other plant families, as no data were collected concerning use of other plant families in the area. Phillips and Gentry (1993a) suggest that the relative importance of different plant groups can be compared by calculating a modified version of the use value. When they calculated ‘family use values’ concerning the use of plants among mestizos in Peru, they found that palms were used more than species from comparable families. Whether the same holds true for other communities remains an open question.

Palm importance

Generally, the different measures of palm use and importance differed greatly between species (Table 4), indicating that species-specific characteristics determine the degree to which a palm is used and esteemed. Importance values were zero or near zero for the majority of species while only one species had a high importance value. Many ethnobotanical studies have implicitly or explicitly assumed that importance of a plant is primarily a function of how many different ways it is used: the more uses, the more important the plant. The validity of this assumption has, however, rarely been tested. In this study, it was seen that there is indeed a positive correlation between palms’ importance values and use values and number of uses (Table 5). At first glance this seems to support the notion of importance being a product of the multitude of applications of a species. Inspection of the data presented here also showed that species with high use values and numbers of uses had high use diversity, but rather low use equitability values (Table 5). This means that for species with a high number of uses the contribution of the different uses to the total utility of that species varied greatly. For the most often mentioned species one or two uses were responsible for most responses while the remaining uses were mentioned only a few times each.

Furthermore, it was seen that there was a positive correlation between informant diversity and palm importance (Table 5). Plants which were regarded as important and could be used for many purposes were used by more people than plants which were not thought to be very important or only had few uses. Informant equitability

Table 4. Summary of quantitative measures of different aspects of use and importance calculated for palm species used by local people in eastern Madagascar. The table gives average values for all species, standard deviations to indicate the spread in values for different species, and minimum and maximum values (in parentheses) recorded. Calculation and content of the different measures are explained in Table 2.

	Mean value (min; max)	Standard deviation
Number of informants	22.7 (2; 52)	13.9
Number of reports	34 (4; 120)	29.3
Number of use types	5.2 (1; 19)	5.0
Importance value	0.05 (0.65; 0)	0.14
Use value	0.63 (0.074; 2.2)	0.54
Use diversity	1.9 (1; 3.2)	0.72
Use equitability	0.66 (0.29; 1)	0.22
Informant diversity	19.0 (2; 36.8)	10.7
Informant equitability	0.87 (0.7; 1)	0.067
Use consensus	−0.16 (−0.93; +0.93)	0.52
Purpose consensus	0.29 (0.023; 0.54)	0.17

values were generally very high, implying that all persons who knew a certain plant knew more or less the same number of uses (Table 4). There was, however, a small but significant tendency for high importance values to have lower informant equitability values, implying that plants, which have a large number of uses and are used by a large number of people, show some differences in the degree to which different people make use of them (Table 5).

Use consensus values showed that most species were used only by few informants while the majority did not use them. Only a few species were recognised as being useful by nearly all informants (Table 4). Consensus about what purposes species were used for was generally low indicating that people use the same species for different purposes, even though they know about the same number of uses for a species (Table 4).

Knowledge distribution among informants

Informants knew on average ten species and fourteen uses each. None of the informants used all of the recorded species (Table 6). Knowledge levels expressed as number of species or uses known did not deviate significantly from a normal distribution indicating that knowledge is commonly shared (Figure 4). Not only were there large differences in the number of uses that people knew, but also in the number of species that they made use of (Table 6). People used the palm species they knew to more or less to the same degree (Table 6).

Stepwise linear regression revealed that informants' knowledge of palms could mainly be related to the number of crops they cultivated, their residence village and

Table 5. Correlations between the importance accorded to a palm and different aspects of its use. Calculation and content of the different measures are explained in Table 2. Direction of correlation is indicated by '+' and '−' signifying positive and negative correlations, respectively. Significance levels of the correlation is indicated by asterisks in the following way: (*) $0.05 < P < 0.07$; *$0.01 < P \leq 0.05$; **$0.001 < P \leq 0.01$; ***$0.0001 < P \leq 0.001$; **** $P \leq 0.0001$; NS: not significant.

	Number of types of use	Importance value	Use value	Use diversity	Use equitability	Informant diversity	Informant equitability	Use consensus
Importance value	+ (*)							
Use value	+***	+**						
Use diversity	+**	NS	+*					
Use equitability	−**	NS	−*	NS				
Informant diversity	+**	+**	+****	NS	−**			
Informant equitability	−***	−**	−****	NS	+**	−***		
Use consensus	+**	+**	+****	NS	−**	+****	−***	
Purpose consensus	−****	− (*)	− (*)	−**	+**	NS	+*	−*

Table 6. Summary of different quantitative measures of informants' knowledge of palm uses. Calculation and content of the different measures are described in Table 3. The table gives average values for all informants, standard deviations to indicate the spread in informants' knowledge, and minimum and maximum values (in parentheses) recorded.

	Mean value (min; max)	Standard deviation
Number of uses	14.33 (1; 33)	6.46
Number of species	9.87 (1; 18)	3.93
Relative use value	1.00 (0.018; 3.4)	0.71
Species diversity	7.99 (1.0; 12. 6)	2.94
Species equitability	0.82 (0.53; 1.0)	0.10

their general wealth. In general, the more crops informants cultivated and the more wealthy they were, the more palms did they cite as being useful (Table 7). Logistic regression applied to data concerning use of palms for rituals showed similar results with a significant negative relation with informants' wealth ($P < 0.05$) and a significant positive relation with the number of crops cultivated ($P < 0.001$). Although regression analysis in itself does not prove causality and the individual models and regression factors should be regarded with caution due to the small sample size, the rather consistent results allow for a few general conclusions to be drawn. The study did not support the common assumption that the poorest people in a community are most dependent on wild products and thus have the best knowledge of wild species. On the contrary, it was the wealthier people who exhibited the greatest

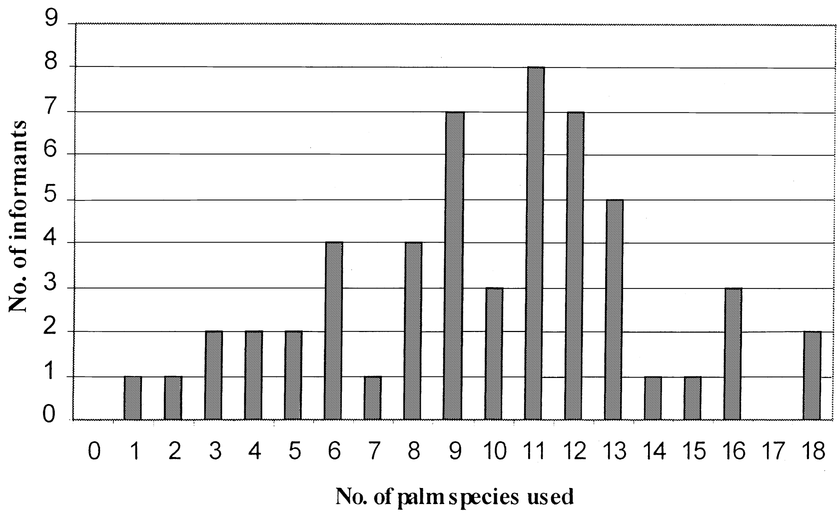

Figure 4. Distribution of palm use and knowledge among Betsimisaraka as indicated by the number of informants who utilise a certain number of palm species. Total number of informants was 54 and total number of palm species mentioned as being useful was 25.

Table 7. Relationship between informants' knowledge of palm uses and their socio-economic circumstances. The relationships were determined by means of stepwise linear regression of different quantitative measures of informants' knowledge about palms onto socio-economic variables. The table includes only those variables which were statistically significant. Transformations of independent and dependent variables are indicated in the table. Apart from the socio-economic variables listed in this table, gender, annual per capita rice harvest and the number of domestic animals were also included in the analyses as explanatory variables, but we did not find statistically significant relationships for these variables. In addition to the variables explained in Table 3, the number of species that informants considered to be useful in each of the categories 'artisanry', 'construction', 'decoration', 'food', 'medicine', 'tools' and 'cultivation' were included in the analysis as dependent variables. Significance levels of the socio-economic variables selected in the stepwise regression procedure as well as the significance level of the whole regression model (P) follow Table 5.

	Village	Age	sq.rt (education + 1)	sq.rt. household size	Roof material	Irrigation	ln (annual rice harvest)	Number of crops	ln wealth	P	R^2
Number of uses	*							+**	+***	****	0.52
Total number of species used	**							+**	+*	****	0.41
sq.rt RUV_i	*							+****		****	0.43
SD_i	**							+****		***	0.33
SE_i								−****		****	0.34
Number of species used for:											
Artisanry								+****		****	0.26
Construction				+*						*	0.08
Decoration			+**		**			+ (*)		***	0.37
Food	****							+**	+**	****	0.52
sq.rt (Medicine + 1)		+*								*	0.08
sq.rt (Tools)						+*	+***	+**		***	0.35

knowledge. The general tendency of the number of crops cultivated to be related to a persons knowledge of palms can be interpreted as being indicative of a persons attitude towards his floristic environment. If people who are inquisitive about nature also have an experimental and entrepreneurial attitude they are more likely to have a good knowledge of wild and domesticated plants. This knowledge can often be converted to a higher living standard, especially in communities where agriculture products are not very diverse. Another possible explanation for the observed positive relationship between wealth and palm knowledge could be that informants were intimidated by the presence of park personnel. Although the protected areas are surrounded by buffer zones where the controlled extraction of certain forest products is allowed, this requires a permission. In addition, some palms have their main distribution within the core protected areas, and collection of some products is therefore probably infringing park rules. If poorer people are the main users of palm products they may therefore also be most unwilling to say so.

The significance of location with regard to a persons knowledge level may partly be a function of differences in surroundings and distance to the forest between the three villages, but may also be due to differences in contact with the outside world. People living in the largest and most accessible of the three villages, village no. 1, showed in most cases less knowledge than in the other two villages. The highest level of knowledge was in most cases exhibited by people living in the most remote village closest to the forest, village no. 3. Although no definite statements can be made as the three villages differed in more than one way, it seems likely that proximity to the forest and availability of external products are important factors regarding the inhabitants' knowledge level. A larger degree of contact with the outside world and a resulting increase in the opportunity to trade and to obtain externally produced goods can probably lead to an erosion of indigenous knowledge as traditional products are replaced by external goods. External products are often perceived as being of better quality and as a sign of high social status – an attitude which promotes replacement even when local products are still abundant. Signs of such replacement tendencies are already becoming manifest in the case of palm thatch which is increasingly being replaced by corrugated tin roofs. In village no. 1, which is the largest village and has more trade and contact to lowland areas than the other two villages, more than two thirds of all houses have tin roofs. On the contrary, in village no. 3, the smallest and most remote village, none of the houses had tin roofs.

Summary and conclusion

One of modern society's Gordian knots is how to satisfy basic needs of a rapidly growing human population while preserving nature at the same time. Ethnobotany can contribute to resolving this problem by clarifying to what extent human communities depend on the surrounding environment and by providing information concerning consequences of specific kinds of exploitation (Phillips 1996). To be able to collect and understand ethnobotanical data correctly it is important to have some insight into the studied culture's own categories and perceptions – the so-called 'emic' approach (Zent 1996). Understanding the emic perspective is not only of scientific value, but also of practical relevance. As numerous failed development and conservation projects have demonstrated, support and involvement of local people is one of the basic requirements for success of any project, whether it aims at reducing human pressure on the environment or to promote economic development (Brandon and Wells 1992; Carpenter 1998). Listening to local people's voices to find out what they perceive as important and/or problematic should therefore be a central part of the planning and implementation of any conservation or development project. However, to be able to compare and evaluate importance of different plant resources and to investigate how knowledge and plant uses are distributed within a society it may often be desirable to translate local conceptions into a quantitative form amenable to statistical analyses. In this study, different measures of palm importance and use were therefore calculated and were then analysed with the aim of investigating which factors influence importance accorded to palms and knowledge levels of the people.

Although at first glance it seems as if importance and utility of palms among the Betsimisaraka are indeed a result of these plants having a large number of uses, closer inspection of the data did not support this assumption unequivocally. Rather, it seems that importance of plants mostly stems from one or two major uses, which are widely recognised, while these plants often are also used for several other purposes, but in a much less consistent fashion. It therefore seems plausible that importance is not as much a product of the number of uses, but rather that it is the other way around: plants which have proven to be important due to their suitability for certain purposes are investigated and experimented with more extensively than other plants. This results in important plants being employed for a larger number of purposes and showing larger differences in the extent and way that different informants make use of them. Such an explanation seems to make intuitively sense, as people might as well try to make use of other parts of plants that need to be gathered anyway.

Differences in informants' knowledge levels are as large as differences in use and importance of different palm species. In general, the more wealthy people exhibit the largest knowledge while there are also large differences between separate communities. Thus, palms seem to contribute positively to rural household economies, while applications and exploitation intensity are influenced by local differences in the natural and economic environment.

Several important conclusions emerge concerning the prospects for conserving useful palms in eastern Madagascar. Firstly, as importance of palms seems to stem from a small number of specific uses, pressure due to exploitation can probably be reduced by finding adequate and affordable substitutes for those major uses. Replacement of some traditional products has already taken place due to new products being perceived as more convenient or superior, as in the replacement of blow dart pipes with shot guns or replacement of woven palm cloth with cotton or other industrially produced fabrics. A current example is the ongoing replacement of traditional palm thatch with corrugated tin. In other cases, replacement is taking place due to the increasing scarcity of the required palm species as in the case of woven hats or use of palm hearts for food. Even though wealthier people apparently are the main users of palm products and can afford substitute materials, major products are used by all community members to the same degree. Therefore an increasing scarcity of some palm products may still have a substantial economic impact on poorer households. Not only will replacement entail an increased dependence on externally derived products and monetary economy, it will also mean loss of a potential source of monetary income from the sale of palm products such as thatch panels or woven mats and baskets.

In addition, traditional knowledge will most likely be eroded. Age patterns did not indicate that such an erosion of the communities' knowledge base is taking place yet, but some of the older informants complained that members of the young generation know some of the traditional products only from hear-say and do not know how to manufacture them any more. Observed knowledge differences between the three studied communities also support the hypothesis that a certain loss of knowledge is taking place as a consequence of replacement of palm products with external products, as knowledge levels generally were highest in the village closest to the forest and furthest from the road, where the availability of external products was lowest.

To preserve the traditional knowledge pool it will therefore be necessary to encourage sustainable use of palms. This may also be ultimately beneficial to the preservation of forest palms as the largest threat nowadays does not seem to stem from overexploitation, but rather from habitat destruction. Replacement in itself will therefore not be sufficient to guarantee the continued survival of palms, while sustainable exploitation schemes, guaranteeing local control with resource access, may provide incentives for forest conservation (Lehmkuhl et al. 1988; Dove 1993). Prospects for sustainable exploitation of the most important palms seem encouraging as main products, such as thatch, are already being the subject of within-village trade and as these palms in addition to marketable major products provide multiple minor products which in many cases can be harvested without damaging the palm.

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Appendix

Palm species and their uses mentioned in survey comprising 54 persons living at the eastern side of the Zahamena protected areas in east Madagascar. Scientific names are followed by voucher no. Byg in parentheses and vernacular name. Conservation status is taken from Dransfield and Beentje (1995). Different folk species have been listed separately even when they are the same scientific species. Species which were identified as useful by field informants, but not mentioned in interviews have been included in the calculation of total species equitability, but not in other analyses. Undocumented folk species were included in the calculation of total species diversity and species equitability as well as in the calculation and analyses of informants' knowledge patterns, while no species specific measures were calculated for them.

Number of informants	Number of reports	Importance value	Uses	Conservation status
Cocos nucifera L. (no voucher) 'Voaniho'				
28	46	0.063	Fruit (food), heart (food), oil (food; hair styling), leaf blade (medicine for digestion; decoration of village entrance, church), pinnae (crosses for church), entire plant (planted at sacred places)	Not threatened (cultivated)
Dypsis? canaliculata (Jum.) Beentje and J. Dransf. (Byg #9) 'Lafaza'				
2	4	0	Heart (food), stem with leaves (decoration of village entrance), entire plant (planted at sacred places)	Unknown
D. crinita (Jum. and H. Perrier) Beentje and J. Dransf. (Byg #17) 'Vonipotsy'				
9	9	0.021	Leaves (thatch)	Rare
D. crinita (Jum. and H. Perrier) Beentje and J. Dransf. (Byg #21) 'Vonidrano'				
0	0	–	Leaves (thatch), leaf sheath fibres (rope, mattress stuffing)	Rare
D. fibrosa (Wright) Beentje and J. Dransf. (Byg #5) 'Ravintsera', 'Vonitra'				
52	120	0.65	Leaf sheath fibres (mattress stuffing; pot scourer; rope; trade), heart (cough medicine; food), inflorescence (broom), leaves (decoration of church; thatch), pith (extraction of salt used as seasoning, cough medicine, and medicine against pancreatic disease and intestinal worms), stem (extraction of edible larvae)	Not threatened
D. lastelliana (Baill.) Beentje and J. Dransf. (Byg #13) 'Menavozona'				
34	43	0.083	Stem (collection of edible larvae), leaves (thatch; decoration of church, village entrance), petiole (rice tray), pith (extraction of salt used as cough medicine, seasoning), leaf sheath tomentum (mattress stuffing)	Not threatened

Appendix. Continued.

Number of informants	Number of reports	Importance value	Uses	Conservation status
D. nodifera Mart. (Byg #6) 'Sinkiara'				
24	34	0.042	Stem (blow pipes, broom, transverse roof beams)	Not threatened
D. nodifera Mart. (Byg #8) 'Ambosa'				
0	0	–	Stem (transverse roof beams)	Not threatened
D. perrieri (Jum.) Beentje and J. Dransf. (Byg #12) 'Tandrokaka'				
15	19	0	Heart (food), leaves (decoration of village entrance, church; thatch), leaf sheath tomentum or prophyll tomentum (mattress stuffing)	Vulnerable
D. pilulifera (Becc.) Beentje and J. Dransf. (Byg #23) 'Tokoravina'				
16	18	0	Heart (food), stem (extraction of edible larvae), leaves (thatch; weaving)	Vulnerable
D. pinnatifrons Mart. (Byg #15) 'Fariovahana'				
18	23	0	Heart (food; cough medicine), pith (cough medicine; extraction of salt used as seasoning), stem with leaves or leaves alone (decoration of village entrance, church), pinnae (crosses for church), stem (broom), inflorescence (broom)	Not threatened
D. prestoniana Beentje (photograph) 'Tavilona'				
27	37	0	Heart (food), leaf sheath (temporary container, temporary rice tray, temporary plate)	Vulnerable
D. tsaravoasira Beentje (Byg #24) 'Tsaravoasira'				
44	50	0.042	Heart (food; medicine for pregnant women), stem (collection of edible larvae; irrigation pipes), leaf sheath (temporary container)	Endangered
D. tokoravina Beentje (photograph) 'Hovotsimpona'				
7	8	0	Heart (food), leaves (decoration of church)	Endangered
D. viridis Jum. (Byg #14) 'Sinkiaramboalavo'				
0	0	–	Leaves (extraction of oil used against skin diseases)	Vulnerable
Dypsis sp. (Byg #16) 'Sinkiaramboalavo'				
0	0	–	Stem (nails)	Unknown
Elaeis guineensis Jacq. (no voucher) 'Palmier à l'huile'				
7	9	0	Heart (food), oil (food)	Not threatened (cultivated)
Marojejya insignis Humbert (photograph) 'Mandangojezika'				
21	30	0.021	Heart (food), leaves (thatch)	Vulnerable

Appendix. Continued.

Number of informants	Number of reports	Importance value	Uses	Conservation status
Raphia farinifera (Gaertn.) Hylander (no voucher) 'Raffia'				
44	95	0.15	Fruits (food), heart (food), leaf sheath fibres (medicine against digestive disorders; slings used in bird hunt; bird cages; house construction; basketry, fish traps), leaves (woven cloth; other woven products; string; rice trays; decoration of village entrance; small crosses for church; burned as incent at church), stem (rice trays; construction)	Not threatened (cultivated)
Ravenea albicans (Jum.) Beentje (Byg #25) 'Romelatra'				
11	12	0	Heart (food), leaves (weaving)	Endangered
R. dransfieldii Beentje (Byg #22) 'Hovotsarorona'				
8	8	0	Heart (food), stem (collection of edible larvae)	Vulnerable
R. lakatra (Jum.) Beentje (Byg #26) 'Lakatra'				
41	64	0	Heart (food), leaves (weaving), stem (irrigation pipes)	Endangered
R. robustior Jum. and H. Perrier (photograph) 'Tamboho'				
22	29	0	Heart (food), leaves (weaving)	Rare
R. sambiranensis Jum. and H. Perrier (Byg #3) 'Anivona'				
22	30	0	Heart (food; medicine against cough, digestive disorders, for pregnant women), stem (collection of edible larvae; irrigation pipes, house construction), leaves (thatch, decoration of church), pith (rice trays)	Vulnerable
R. sambiranensis Jum. and H. Perrier (Byg #11) 'Ferinempoka'				
0	0		Heart (food)	Vulnerable
Ravenea sp. (photograph) 'Lavafe'				
25	26	0	Heart (food), stem (extraction of edible larvae; house construction)	Unknown
'Bireso' (no voucher)				
1	1	–	Heart (food)	Unknown
'Hovobola' (no voucher)				
2	2	–	Heart (anti-poison), pith (extraction of salt used as medicine against cough)	Unknown
'Hovopariaka' (no voucher)				
1	1	–	Heart (food)	Unknown
'Mangitranana' (no voucher)				
41	56	–	Heart (food), stem (extraction of edible larvae; house construction; irrigation pipes), leaves (weaving, decoration of church)	Unknown

References

Brandon KE and Wells M (1992) Planning for people and parks: design dilemmas. World Development 20: 557–570

Carpenter JF (1998) Internally motivated development projects: a potential tool for biodiversity conservation outside of protected areas. Ambio 27: 211–216

Dove MR (1993) A revisionist view of tropical deforestation and development. Environmental Conservation 20: 17–24

Dransfield J and Beentje H (1995) Palms of Madagascar. Royal Botanic Gardens, Kew and The International Palm Society, Lawrence

IUCN (1991) Protected Areas of the World – A review of National Systems. Vol. 3: Afrotropical. IUCN – The World Conservation Union, Cambridge

Lehmkuhl JF, Upreti FK and Sharma UR (1988) National parks and local development: grasses and people in Royal Chitwan National Park, Nepal. Environmental Conservation 15: 143–148

Phillips OL (1996) Some quantitative methods for analyzing ethnobotanical knowledge. In: Alexiades MN (ed) Selected Guidelines for Ethnobotanical Research: A Field Manual. Chapter 9, pp 171–197. The New York Botanical Garden, Bronx, New York

Phillips O and Gentry AH (1993a) The useful plants of Tambopata, Peru: I. Statistical hypotheses tests with a new quantitative technique. Economic Botany 47: 15–32

Phillips O and Gentry AH (1993b) The useful plants of Tambopata, Peru: II. Additional hypotheses testing in quantitative ethnobotany. Economic Botany 47: 33–43

Zent S (1996) Behavioural orientation toward ethnobotanical quantification. In: Alexiades MN (ed) Ethnobotanical Research: A Field Manual, Chapter 10, pp 199–239. The New York Botanical Garden, Bronx, New York