Conservation Status and Economic Potential of *Parajubaea sunkha*, an Endemic Palm of Bolivia

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Parajubaea sunkha **Moraes, one of three species of an endemic Andean genus, is known exclusively from 1700 to 2500 m above sea level within the province of Vallegrande, department of Santa Cruz in Bolivia (Fig. 1 & Back Cover). Early data suggested that *P. sunkha*, a locally important economic species, could be the most threatened of all Bolivian plants (Ibisch 2004a). However, more detailed studies for an adequate assessment were lacking. Now, in the present paper, for the first time, the species' conservation status and threats are assessed quantitatively.**

Perhaps due to its rarity and the lack of taxonomic studies, *Parajubaea sunkha* was not distinguished from *P. torallyi* (Mart.) Burret until recently (Moraes 1996). The first and only contribution on the ecology and use of the species was provided by Vargas (1994). According to this author, the species' habitat is characterized by a mean annual precipitation of about 550 mm with a marked dry season of at least five months, usually between June and October. In the dry season frosts can occur at night. The adaptation of *P. sunkha* to the

1. Typical stand of *Parajubaea sunkha*, east of the town of Vallegrande, Bolivia (photograph J. Enssle).

climate of the high Andean valleys makes the palm suitable for warm-temperate and subtropical localities worldwide.

The seedling prefers shade, while the mature tree is favored by direct sunlight and suppresses accompanying vegetation by closing the canopy. In the heavily shaded *Parajubaea* understory, a humid temperate microclimate and humic topsoil formed by rotting palm leaves provide ideal conditions for germination of the palm seeds. After pollination, fruits reach maturity in about 20 months. The seeds are distributed by rodents who feed on mesocarp of fruits fallen to the ground. Under natural conditions, the seeds require 17 months for germination (Vargas 1994), but with the help of *in vitro* cultivation the germination time of *P. sunkha* and *P. torallyi* can be reduced to only several weeks (Ibisch 2004b). When undisturbed, the palm can display abundant regeneration in its natural habitat. Grazing, land-clearing, burning and harvesting of the palm's fibers, however, all negatively impact regeneration of this rare species.

Parajubaea sunkha is known to occur naturally on only 14 sites within a 300 km^2 range in the province of Vallegrande, department of Santa Cruz (Vargas 1994). The authors estimate that the overall population size comprises about 25,000 mature individuals. In the study region farmers typically possess ~4 ha of cultivated

2 (left). Harvest of fiber by climging. 3 (right). Harvest of fiber using a log as a ramp. (photographs J. Enssle)

land. Maize and wheat are the main staple crops, while potato is the only cash crop and is restricted to irrigated areas. Livestock, mainly cattle, sheep and pigs, serve as capital and are sold only in emergencies when money is needed for materials or for medical care. The limitations for earning money in the rural areas is reflected in the high migration rate of young people from the rural areas to urban centers, leaving many farm households with only grandparents and children. It is in this context that we have to understand the use of the *palma zunkha* (local name), which plays an important role in daily life of local farmers: they use its leaves as forage for cattle and for making baskets and fans (Vargas 1994).

The soft fiber that grows at the petiole base can be harvested annually and is processed and manufactured into mattresses, saddle pillows and ropes. Although the harvesting method is non-destructive for the individual, it results in a total loss of all flowering and fruiting inflorescences, leaving the tree without offspring. Vargas already observed that palm stands exploited over several years have a population structure heavily biased towards mature individuals with scarce rejuvenation.

Parajubaea sunkha suffers both from habitat destruction and overexploitation. Although apparently endangered, it has not yet been included in a CITES appendix, nor was it on the 2004 Red List of the IUCN Species Survival Commission because of insufficient data about the remaining population. Nonetheless, the Bolivian non-governmental organization "Fundación Amigos de la Naturaleza" (Friends of Nature Foundation) developed a conservation project applying *in-situ* and *ex-situ* measures. Strategically, it was intended to achieve conservation by providing increased incomes for local farmers through international commercialization of *Parajubaea* as an ornamental plant.

The objective of this paper is to integrate biological and socio-economic data in order to get a better picture of the actual conservation status and the socioeconomic factors that may have an impact on the palm population and its use. Additionally, we assess if an economic use of *P. sunkha* as ornamental plant or as a non-timber forest product is viable when tendencies of land-use change are taken into account.

Methods

Selection of the study site. Most of the 14 sites where *P. sunkha* naturally occurs are either very remote and difficult to access or the number of individuals is so low that the palms are not used for fiber extraction (Fig. 1). Therefore, the present study focuses on the two main stands east of the town of Vallegrande (UTM/ Prov.SAM56: 0399490E, 07951853N) where we estimate that 70% of the entire population of *P. sunkha* occurs and where, due to its local abundance, the pressure of fiber extraction is highest.

Rapid rural appraisal (RRA). We conducted a RRA of the socioeconomic factors that influence the population dynamics of *P. sunkha* through semi-structured interviews with 21 farmers. We estimate that 90% of all farmers who harvest palm fiber commercially were surveyed. Interview questions covered aspects of land use, socioeconomic situation of the families, past and current market prices for palm fiber products and management practices applied to the *palma zunkha*. In the town of Vallegrande, two merchants who trade palm fiber were interviewed about dynamics of the regional market and about the potential for palm fiber commercialization.

Palm population inventory. As internationally standardized methodologies for the inventory of palm trees do not exist, we decided to establish transects of 500 × 20 m (1 ha), each belonging to a different farm property and considered representative of the palm stands east of Vallegrande. For each tree, we recorded height at leaf base, number of inflorescences, date of last harvest and signs of anthropogenic

4. Weighing the fiber (photograph J. Enssle).

5. Merchant, presenting her innovative mattress. The mattress will be finished with a cotton cover. (photograph J. Enssle).

injuries such as broken or burned trunks. Regeneration was assessed in 25 m^2 plots at the two extremes and middle of each transect.

Fiber productivity assessment. Fiber productivity was assessed by polynomial regression, with fiber produced per tree approximately one year after last harvest as the dependent variable, and tree height multiplied by diameter at breast height (DBH) as the independent variable. In November, 2003, the fiber of 119 trees was harvested and weighed using a spring balance (Figs. 2–4).

Results

Findings of the rapid rural appraisal related to Parajubaea sunkha. Most farmers interviewed in the study region do not have access to irrigation water and, thus, their agricultural mode is subsistence farming. Their only monetary income is generated by working off-farm or by harvesting *Parajubaea* fiber. Access to the regional and national market has improved since 1984, when a road was constructed linking the study area with the town of Vallegrande. The standard daily wage for agricultural work in the study region is $US 2.50.

Farmers and the two main palm fiber merchants in town reported that prices for palm fiber dropped from $US 2.50 to $US 0.80 per unit of 12 kg between 1993 and 2003, possibly due to increasing availability of synthetic substitutes. As a consequence, fiber harvesting is becoming less and less profitable. Only the more innovative and technically sophisticated palm fiber mattresses with springs and a cotton cover still sell well (Fig. 5).

Palm population inventory. While saplings were rather abundant in all four sample stands, the size class of 0.5 m tall palm trees was scarce in two stands and completely missing in the remaining two stands (Fig. 6). None of the palms in the inventory were higher than 8 m. Almost all palms between 0.5–2 m were harvested annually and thus experience the strongest exploitation pressure. In all four sample stands signs of anthropogenic injuries were common. On average 60% of palms had stairs cut into their trunks to climb them easier, about 5% had burned trunks but still lived, about 2% were found dead (either burned, cut or broken by wind) and almost 45% of all palm trees were harvested within the last year, and thus did not generate offspring.

Fiber productivity. Individual palm trees produced between 0.1 and 1.8 kg of fiber annually (mean 1 kg, n=119). Tree height multiplied by DBH explained 66% of variation in fiber production ($R^2 = 0.66$, $P < 0,001$, $n = 119$) (Fig. 7).

Discussion

Population structure. The abundance of different age classes deviated from that expected for undisturbed forest stands (in which age class abundance should decrease exponentially). The enormous loss of individuals in the early stages (saplings and rosettes) may partially be explained by natural die-off. The under-representation of 0.5 m high palms, however, implies that for some time in the past little or no regeneration took place in the sampled palm stands. The questions are what factors caused this unbalanced population structure, and could they still be impacting the conservation status of *P. sunkha*?

The absence of palms around 0.5 m of height (ca. 20 years old; personal communication by Vargas and various farmers) at two sites can be traced back to the construction of a road that connects the stands with the town. Before the road was built, farmers transported fiber on their backs or with donkeys to the local market. This limited them in terms of the quantity they could transport and facilitated the continuing fructification of adult palms to ensure future regeneration. Since the road was built in 1984, it became possible to transport much larger quantities of palm fiber. Farmers confirm that in this time almost all palms were under exploitation. As a result, the regeneration of the species almost came to a halt. The palm stands with no 0.5 m tall palms were directly adjacent to the road and more heavily exploited (Fig.6 S1+S2). The other stands studied were about an hour's walk from the road. Exploitation in these palm stands was not as intensive and some regeneration could occur as shown by the presence of more young palms 0.5–1 m tall (Fig 6 S3+S4).

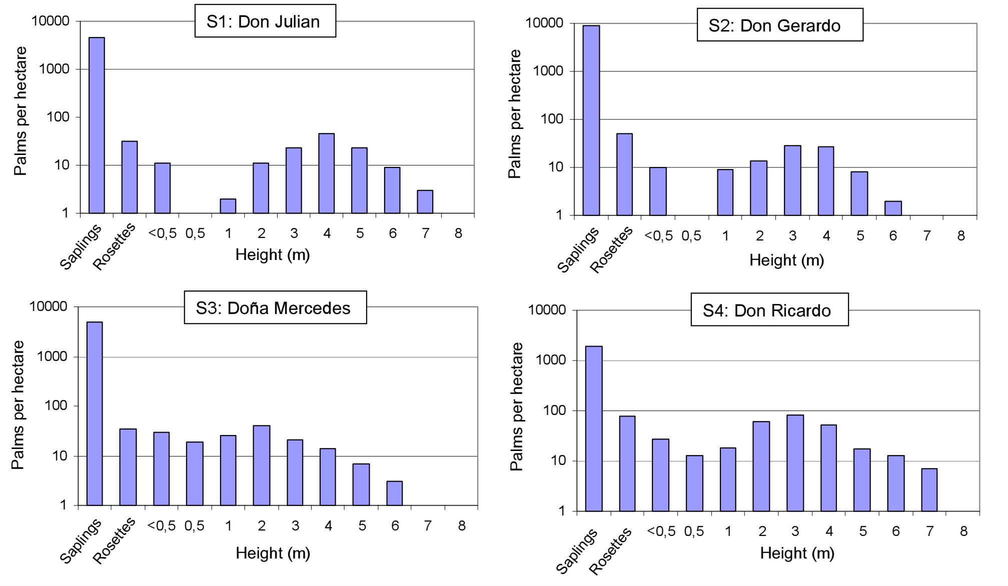
The abundant regeneration of young palms in the last 5 years (approximate age of rosettes) is evidence of the changing dynamics of the palm fiber market. The wider usage of synthetic substitutes, such as nylon, caused a decline of the market price for palm fiber. Farmers once earned between $US 2.0–2.5 per unit of fiber (12 kg), but recently earned only $US 0.8–1.2 per unit. However, to be profitable, farmers need a minimum price of $US 1.5 per unit. As a result, harvest intensity declined and far more trees were able to develop their fruits. Decrease in use has led to increased opportunity for regeneration of the species.

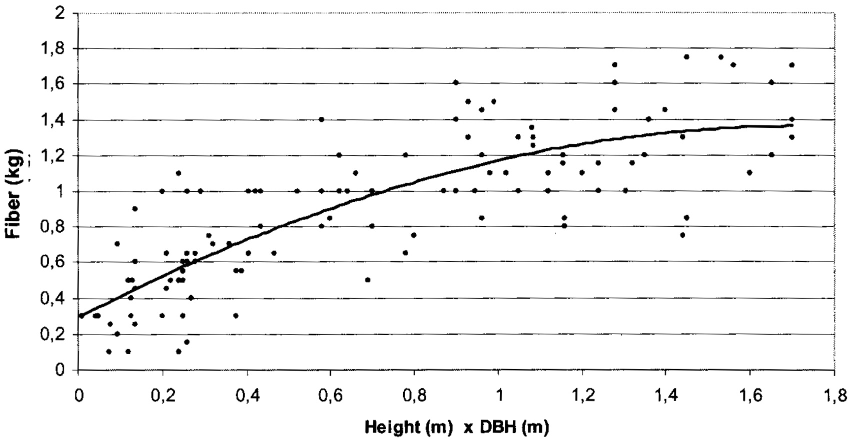
Despite this positive effect, mortality remains high. Most young plants naturally do not survive long-term. However, mortality seems to be increased anthropogenically. Since the palms grow on agricultural lands, saplings and rosettes are frequently victims to browsing livestock (Fig. 8). During the dry season, the young palms are often the only green forage available. Man-made fires and extensive land clearing for agriculture further impede recruitment.

Another interesting question is why the palms' maximum height in the four heavily exploited sample stands does not exceed 8 m (Fig. 6), whereas the palm naturally grows up to 15 m. The explanation is unambiguous: Farmers stated that they felled trees higher than 8 m because the natural production of fiber from this height onwards undergoes a disproportionate reduction. Moreover, harvesting such trees is not economically viable taking into account the additional personal risks of climbing such high palms. The inventory showed that farmers prefer trees 0.5–3 m tall. They are easy to climb, highly productive and provide the best quality fiber. Where arable land is scarce, the palm is a direct competitor to agriculture and is removed as soon as it ceases to be profitable.

Fiber productivity. The amount of fiber that a palm tree produces may depend on three main factors: diameter, tree height (an indicator of light availability or other environmental factors) and habitat (soils, climate, etc.). Given the palm's habitat was relatively homogeneous, the best predictor for fiber production

6. Population structure of four palm stands





7. Fiber production one year after last harvest correlated with height and diameter (DBH = diameter at breast height) (R^2=0.66, $P < 0.001$; n = 119, $y=0.2892 + 1.2409x - 0.3584x^2$).

was a combination of tree height and DBH. Our results can be used to predict harvest volumes and indirectly the economic value of a specific palm stand for its owner. However, farmers may select palm trees for harvest based not only on fiber production but more so by height, sometimes harvesting only trees <3 m tall for reasons stated in the previous paragraph.

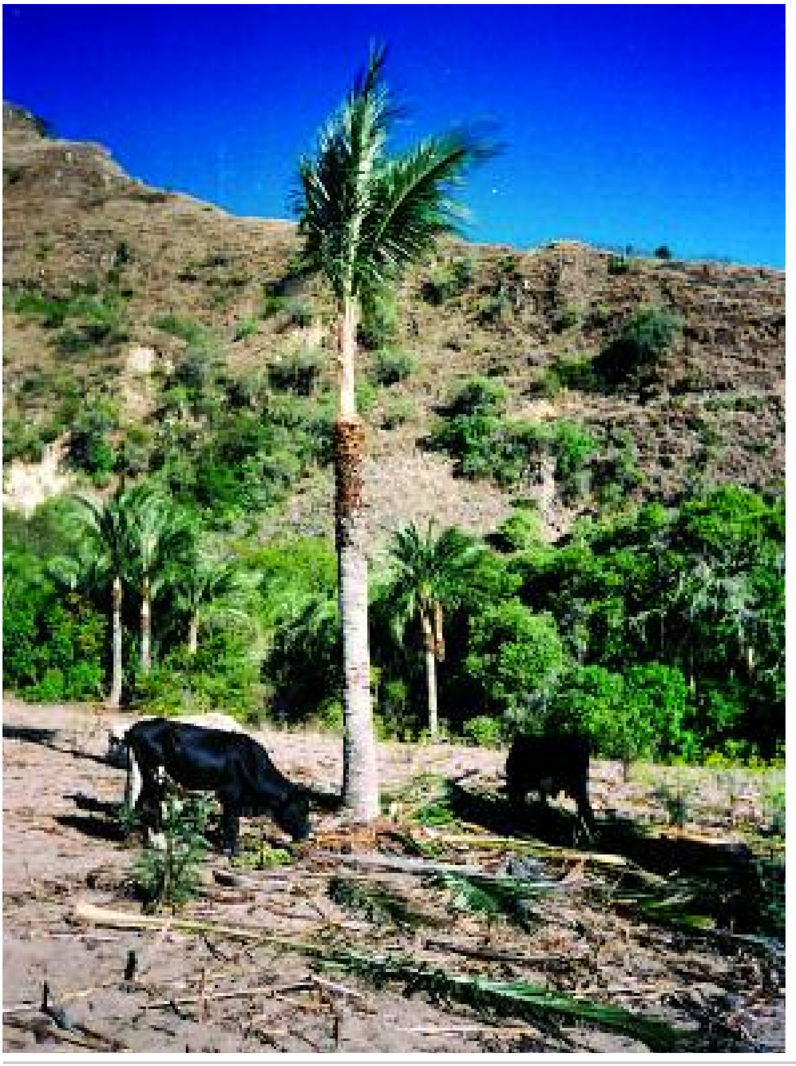
The palm and its economic potential

Fiber commercialization. When market prices for palm fiber were favorable (~$US 2.5 per 12 kg), a farmer had to harvest about 5 trees (average 1 kg each) to earn $US 1. If prices continue at current levels (~$US 0.8 per unit), he has to harvest about 16 trees to earn $US 1. An experienced person needs about 15 minutes to harvest one tree. In order to earn $US 1, at recent prices, a farmer would need to work for 4 hours. These calculations do not include the additional time needed for transport and negotiations with the merchants in town. Compared to the minimum standard wage of $US 2.5 per day for agricultural work, at current low prices palm fiber extraction is only slightly profitable.

The economics of the merchant in the town of Vallegrande, however, appear different. The merchant adds value to the raw fiber by combining it with cotton and metal springs and processing it into high quality mattresses (Fig. 5). This manufacturing process takes two days. One of these mattresses can be sold for about $US 110 on the national market. The profit per mattress for the merchant is around $US 40. Taking the current price levels for raw palm fiber (~$US 0.8 per unit), a farmer – who needs one day to harvest the fiber necessary for one mattress – earns only $US 1.6. Nevertheless, the merchant has a series of additional indirect costs such as store rental, employee wages and advertising.

In conclusion, if prices for raw palm fiber stay at the current low levels, it is obvious that farmers will change their agricultural practices, and as arable land in the region is scarce this may well have deleterious consequences for *P. sunkha*. Even if the managed commercialization of palm fiber as a 'Non Timber Forest Product' improved prospects for the conservation of this palm, lack of access to new markets, declining market prices, lack of infrastructure and limited resource supply are obstacles to achieving sustainable harvest goals.

The palm as an ornamental plant and a genetic resource. Another opportunity to conserve the species is its commercialization as an ornamental plant. As aforementioned, *P. sunkha* is one of the more frost-tolerant palms and as such might be suitable for regions with a warm temperate climate. In 2004, web-based offers for packages of 100 seeds ranged from $US 40–90. The important question, however, pertains to the method by which such seeds can reach the market. While the import of rare palm species may be legal, the uncontrolled export of such species from Bolivia is illegal. Farmers of the region, currently, do not earn any real income or derive any benefit from this unregulated business while they should and actually could when fair and governmentally approved projects came into existence.



8. Young palms are frequently browsed by cattle, which also feed on leaves cut during harvest.

Currently, any unapproved export of genetic resources is violating Bolivian law. *Parajubaea* clearly has to be considered as a genetic resource, and therefore article 15 of the Convention on Biological Diversity (CBD) and Decision 391 of the treaty of Cartagena (in Bolivia: Decreto Supremo 24676, Art. 3) on access to genetic resources must be applied. According to these regulations, "the authority to determine access to genetic resources rests with the national governments and is subject to national legislation" (CBD Art. 15.1). Unfortunately the implementation of the Bolivian legislation is currently hindered by severe socio-political problems. Until now, the 'access and benefit sharing' regulations have not stimulated novel bioprospecting activities or innovative uses of genetic resources and Bolivian society failed to generate any benefits (Galarza 2004, Ibisch 2005). It may be difficult to get official Bolivian approval for trade of a genetic resource, but irrespective of such regulations, if species like *Parajubaea sunkha* are propagated and horticulturally developed in large quantities abroad, the consequences may be disastrous. Without enjoying some form of spin-off benefit, local people will probably lose interest in conserving *Parajubaea sunkha* in its natural habitat.

Use it or lose it? The future of *Parajubaea sunkha*

It is a dilemma. Although pressure of palm fiber harvest has decreased in the last few years and regeneration is increasing, the conservation of this rare palm species is by no means secure. To the contrary, the conservation status may worsen due to extension and intensification of livestock production and agriculture because palm fiber is no longer a viable income alternative. The story of *P. sunkha* may validate the motto "use it or lose it." The underlying assumption behind the idea that NTFP (Non-timber Forest Products) exploitation can promote biodiversity conservation is that people will ensure the reproductive capacity of products that are valuable sources of income (Fisher and Dechaineux 1998). As with most natural resources, there is a potential contradiction between the utility of the species and its long-term prospects for survival: high demand may lead to over-exploitation, whereas low demand may lead to land clearing for other agricultural purposes with subsequent reduction of the remnant population.

Conservation of *P. sunkha* through sustainable commercialization of its fibers faces uncertainties and might not be viable. A detailed market analysis is still needed to evaluate this question. Commercialization of the palm as an ornamental plant may have more economic potential, but mechanisms need to be created to assure the conservation of the natural resource in its habitat. Among others, a necessary precondition is the application and enforcement of the existing Bolivian legislation. The establishment of a protected area at the municipal, departmental or national levels should be heavily promoted. Meanwhile, it is important to monitor the palm's conservation status and its population dynamics. The inclusion in the 2006 Red List of the IUCN Species Survival Commission that was proposed and accepted as result of this study hopefully will bring more international attention to this endangered palm species.

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