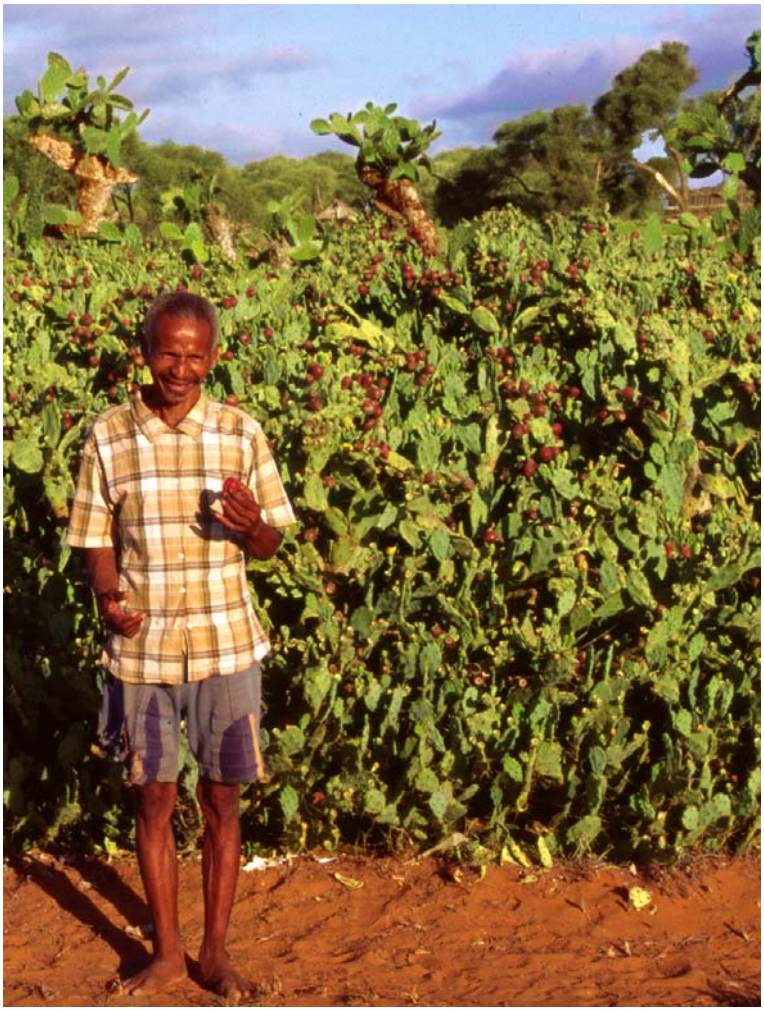
Minor Field Studies No 285

Introduced *Opuntia* spp. in Southern Madagascar: Problems and Opportunities

Per Larsson



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Abstract

Several *Opuntia* species have been introduced to southern Madagascar and are today affecting the local economy. Especially the species *Opuntia stricta* has been recorded as a dangerous weed. The information about which species that are present and how they are affecting the life of the people in southern Madagascar has not earlier been described. In this study this information was collected using a semi-structured, open-ended interview technique. The aim was to describe how the *Opuntia* species are affecting the human livelihood and to describe the economical and nutritional importance of *Opuntia* spp. in ten study sites located in the Androy region in south Madagascar. In total 27 different Opuntia variants with local names was recorded and six of them was present in all study sites. Two species were having more impact than the others: 1) *O. ficus-indica* which fruit is an important food resource for humans and the cladodes are given as fodder to the livestock. 2) *O. stricta* which is a serious weed strongly affecting the economy and livelihood negatively in this region. The effect of *O. stricta* can be summarised in three categories: i) a weed problem. ii) loss in livestock. iii) a health problem. The important pastoralism in Androy is today highly depended to *O. ficus-indica* but seriously threatened by *O. stricta*.

Introduction

Introduced invasive species are ranked as the second most important factor causing biodiversity loss worldwide (IUCN, 2000). *Opuntia* spp. (Cactaceae) represent one such group of species affecting large areas where they have been introduced e.g. in Australia (Dodd, 1940), South Africa (Hoffman et al., 1998; Volchansky et al., 1999), India, Kina (Mack, 2003), Spain (Gimeno & Vilà, 2002), Ethiopia, Mauritius (Fowler et al., 2000; Greathead, 1971), Kenya and Reunion (Greathead, 1971).

In Madagascar there are numerous examples of introduced species causing dramatic changes to the agricultural sector (Goodman and Patterson 1997, Goodman et al. 2003). However, the introduction of *Opuntia* in Madagascar is a striking example of how introduced species may rapidly significantly influence the local economy. Several studies have even argued that the current dominating pastoralism in southern Madagascar could not have developed to its current level without the introduction of *Opuntia* (Binggeli 2003, Middleton, 1999; Kaufmann, 2001).

The first *Opuntia* species (*raketa* in Malagasy), were introduced to Madagascar in the late 18th century. The French colonial forces used *Opuntia* to construct a living fence against intruders around Ft. Dauphine in 1768 (Binggeli in press, Middleton, 2002). It is unclear which Opuntia species it was but Binggeli (2003) suggested *Opuntia monocanta*. However, in a few decades, the cactus was observed to be used by local people as living fences around village gardens and agricultural fields and had, by this time, become a common sight in southeast Madagascar. In the late 19th and early 20th century, raketa increased in abundance with one region being named *région cactée* (cactus region) (Binggeli in press, Kaufmann, 2001; Middleton, 1999, 2002; Hošek, 2001). The rapid dispersal of this *Opuntia* is assumed to be a result of the cactus representing an important complementary fodder for livestock when there was lack of grass. Furthermore, the fruits of the cacti were maturing during December –March, usually a time with a scarcity of food for humans (Binggeli, 2003; Middleton 1999). However, the cacti also caused problems in agriculture. When fields started to get overgrown by raketa these sometimes became abandoned since it took too much labour to clear the fields. There were also problems related to the spines, since the small hair-like spines could cause lung problems and the livestock suffered mortality due to intestinal inflammations caused by the large hard spines (Binggeli, in press).

In 1923 the cochineal louse (*Dactylopius* sp.) was introduced in Madagascar. In the south the cochineal louse spread from Toliara in 1924 and was infesting the raketa area with a speed of 100 km per year (Frappa, 1932). Within only four years the raketa was wiped out from many areas in southern Madagascar causing a collapse in pastoralism with tens of thousands of cattle dying. A severe famine followed and many villages were abandoned. In the Tsihombe district half of the population of 60,000 people died or migrated as a result of the epidemic (Deschamps, 1959). It is still debated whether the French colonial administration deliberately introduced the cochineal or not (Middleton 2002, 1999, Kaufmann, 2001; Binggeli, in press). In 1930 new spineless and cochineal resistant *Opuntia* species[1] were introduced and *Opuntia* again became an important base for the economy in the south.

[1] *Opuntia ficus-indica* var.

O. stricta (Haw.) Haw., is today one of the naturalised Opuntia species in the area of south Madagascar. It is originating from the south of North America and is classified by IUCN as being among the 100 of the worlds worst invasive plant species (IUCN, 2000). It has for some years caused problems in the Androy area because of the performance as a well spreading weed in pastures and agriculture fields (ANGAP et al. 2001).

The aim of this study was to document how and when different species *Opuntia* were introduced in the Androy area and to describe the current management techniques employed locally for managing and controlling *Opuntia* populations.

Questions:

1. To what extent does *Opuntia stricta* impact on human livelihood in Androy, Madagascar
2. Is the degree of impact correlated to the time elapsed since introduction?
3. What is the economical and nutritional importance of other Opuntia species?

Methods

Study sites

The study was carried out in the Androy surrounding region, in central southern Madagascar, ranging from the Karimbola Plateau region in the west to the slopes of the mountain range east of the Mandrare river. The survey was performed in the following sites: Tranoroa, Tsimilofo, Beloha, Barabay, Lavanono, Soamanitse, Cape St Marie, Marovato, Ankilimasy and Antaranta (Fig 1.). The study sites were chosen to follow a north - south and an east - west transect with a common point in Lavanono, which was one of the two first introduction sites of *Opuntia stricta* known as *raketamena* in Malagasy (Elmqvist pers. comm.)

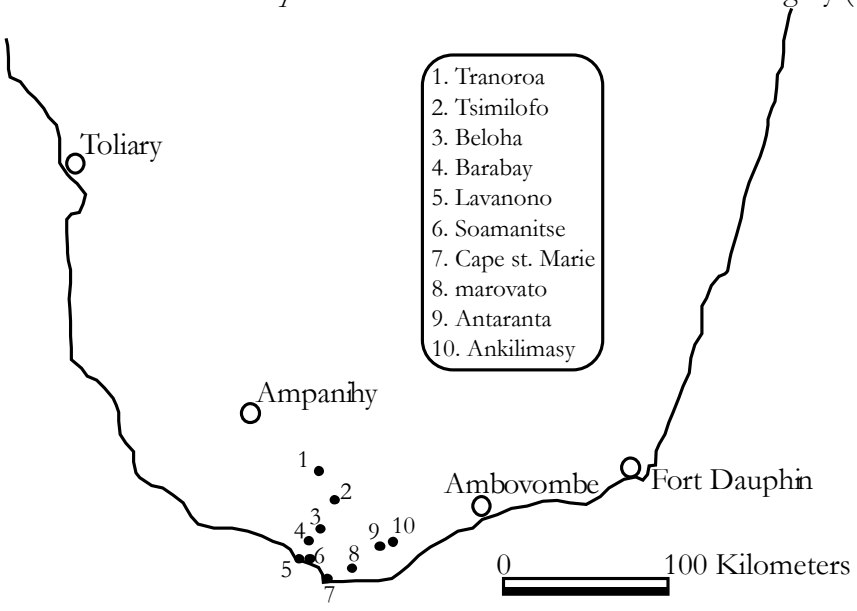

Fig 1. Study area and study sites in south Madagascar

Social survey

Fieldwork was carried out during six weeks in November and December 2003 using an in depth, semi-structured, open-ended interview technique with the inhabitants of the Androy region, the Tandroy people. The social organisation of rural Madagascar is based on the *fanjakana*, representing the formal institutions of Malagasy society, and the traditions and customs represented by the more informal aspects of the institutional framework (Lingard et al. 2003). Identification of the person(s) in control of management functions is crucial, and includes, in addition to the *fokontany* (administrative level), the *fokonolona,* led by clan leaders. The informants of this study were both key persons in each locality, such as representatives of *fokontany, fokonolona* leaders, mayors, local guides, as well as ordinary inhabitants. The informants were asked questions about time of introduction, current abundance of different varieties of *Opuntia,* their uses and how management was employed locally.

Semi-quantitative estimates

1) *Estimates of importance.* A string with a loop was used where the loop could be moved along the string. One end of the string represented the raketa being of little or no use or even economically detrimental, while the other end represented the raketa being of high economic and social importance. The informant was asked to place the loop along the string to indicate the importance for each variety of raketa being analysed. The placement of the loop was then transformed to a number where 8 was maximum (good) and 0 minimum (bad).

2) *Estimates of relative abundance.* To get some kind of measurement of how abundant the different raketa were compared to each other, 20 beans was used. The person that was interviewed was asked to identify a number of groups where each group represents the abundance of a raketa e.g. if $raketa_1$ was twice abundant as $raketa_2$, $raketa_1$ should have twice as many beans in the group than $raketa_2$. There was no statistical test made on these values since the sampling of persons and collected data may be heavily biased due to different perceptions among respondents.

Results

Interviews

In total, 78 persons were interviewed during this study as shown in table 1

Table 1. *The number of interviews in the different localities*

Locality	Number of interviews
Tranoroa	11
Beloha	11
Tsimilofo	9
Barabay	10
Lavanono	8
Soamanitse	9
Cape St. Marie	5
Marovato	8
Ankilimasy	3
Ataranta	4

Local taxonomy of raketa

There were a totall of 31 different names on the raketa variants in the visited areas. Some variants were named differently in different areas, which resulted in a total of 27 name variants in the ten study areas. There were six raketa that were present at all the study sites e.g. *raketasonjo* (*O. ficus-indica*), *raketambazaha*, *raketanosy*[2], *raketamena* (*O. stricta*), *raketabefatike*[3] and *raketagasy*. Also the *raketakopake*[4] was present at all but two study sites. All the raketa names and the distribution of variants are presented in appendix I. Ankilimasy was the most diverse study site with 16 different raketa variants, and Lavanono and Antaranta were the localities with the least number, only eight raketa varieties.

History of the introduction of *Opuntia* spp.

The history of the introduction of the different raketa to Madagascar varies. Both the year of introduction and the way the raketa was introduced varies between and within the species. There are also different stories within the same locality about how the raketas were introduced. Not every interviewed person could answer the question of when he or she was observing the different raketa varieties for the first time and how it was brought to the locality. Totally 49 persons gave information relating to the time of introduction (Appendix II).

Relative abundance and usefulness of Raketamena, Raketasonjo, Raketambazaha and Raketanosy

In the interviews on perceived raketa relative abundance, *raketamena* was ranked the highest with a median cover of 47 % (n=55) of all raketa cover. The next most abundant raketa was *raketasonjo* with a median of 22% (n=55). The less abundant were *raketambazaha* almost 16% (n=50), *raketanosy* 13% (n=44) and *raketakopake* almost 8% (n=14). Remaining raketas had a cover of less than 5 %. There are differences in the medians recorded between the study sites as shown in table 2

Table 2. *The relative abundance of Raketamena, Raketasonjo, Raketambazaha and Raketanosy in per cent. n = number of informants at the location, N= total number of informant that menaced the raketa*

Raketa	*sonjo*	n	*mbazaha*	n	*nosy*	n	*mena*	n	*kopake*	n
Location	%		%		%		%		%	
Ankilimasy	33	3	19	3	12	2	33	3	0	0
Antaranta	28	3	16	3	18	3	41	3	0	0
Barabay	17	9	17	9	17	7	44	9	11	2
Beloha	25	7	11	7	14	7	47	7	5	1
Cape st. Marie	24	4	14	4	06	4	54	4	6	3
Lavanono	2	7	19	7	18	5	47	7	0	0
Marovato	18	7	14	7	11	4	67	7	8	2
Soamanitse	18	7	16	7	12	5	53	7	5	1
Tsimilofo	33	8	10	3	19	7	39	8	11	5
Median cover %	**24**	N=55	**16**	N=50	**14**	N=44	**47**	N=55	**7**	N=14

[2] Also called *Raketabe*

[3] Also called *Raketamahararake*

[4] Also called *Raketaandambo* or *Raketaborivoa*

In the survey of ranking usefulness *raketasonjo* was the raketa with the highest overall ranking and had a median value of 8 (n=60). The following most useful were *raketambazaha* 7,75 (n=54), *raketanosy* 7 (n=50) and *raketakopake* 5 (n=19). *Raketamena* was ranked lowest with a median of 0 (n=60).

There was no correlation between the perceived raketa relative abundance and the ranking of usefulness between the study sites. At all study sites raketasonjo was ranked high and Raketamena low, independent on the perceived relative abundance of the raketa.

Human uses of raketa

There are several raketas that are used as important resources for the survival of people and livestock in southern Madagascar.

Fruits

All present *Opuntia* in the study sites produce fruits. However, fruits of only some of the raketas were eaten frequently e.g. *raketasonjo*, *raketambazaha*, *raketanosy* and *raketakopake*. The fruit of the other raketas were also eaten but some species had fruits with a bad taste. The fruits of *raketamena* and *raketabefatike* were seldom used other than during periods of severe food shortages, due to inferior taste and perceived stomach problems after consumption. The most frequently consumed raketa was *Raketasonjo* where the fruits have a high water content. Informants stated that during some months two or three meals per day consist entirely of raketa fruits. Estimates from informants revealed that one adult might on average consume 10 litres of fruits of *raketasonjo* or 50-70 fruits each day. The fruits of *raketambazaha* and *raketanosy* mature during December and are harvested in the next two to three months. *Raketasonjo* mature in late December to February and can be harvested for several months depending on the resources. The fruits of *raketasonjo* can also be stored for six months up to one year.

Cladodes

All of the raketas except *raketamena*, *raketamadinke*, *raketamadam*, *raketabefatike*, *raketakoak*, *raketabesofy* and *raketagasy* are used as fodder for the livestock and zebus. In raketas with spines, the cladodes are burned, to get rid of the spines, before they are fed to the animals. The cladodes can be given whole or chopped in pieces. Several persons were saying that they could not keep their zebus if they did not have raketa to feed them. During the dry months the zebus are given *raketasonjo* cladodes. These cladodes have a high wather content and there is no need for additional water to be given to the zebus. The zebus are fed with raketas from May until the rains are coming, which is usually November-December but in some years the first rain does not come until January. In some years the zebus are fed with raketa all the year around. Occasionally people also consume cladodes of *raketasonjo* and *raketambazaha* in times of food scarcity. The cladodes can be eaten raw, grilled or cooked.

Water resource for humans

The southern part of Madagascar is very dry. The scarce water recourses have always affected peoples lives. It is possible to extract water from the raketa cladodes. The cladode is cut in two pieces and water is extracted from the mesophyll. Either the mesophyll is just squashed or mixed with crushed bark from *Rohondrovy (Alluaudia)* or *Kibay*. It was stated that it is possible to extract 8-10 litres of water from 15-20 cladodes (oral reference Soamanitse).

Cultivated raketas

There are several cultivated raketas. The most frequent are *raketasonjo* and *raketambazaha*, but *raketanosy*, *raketakopake*, *raketasomizo raketa(be)vonongig* and *raketaborivoa* are also planted. The raketas are planted both as fodder and for the fruits, and both *raketasonjo* and *raketambazaha* are planted as an ordinary crop on fields with beans, cucumber, corn etc. The raketas were planted by putting one cladode in the ground, the cladode then producing roots and after two to four years (depending on species and locality) the plants began fruiting. When the spineless *raketambazaha* is planted, it is necessary to have it in fenced off to keep the livestock outside the plantations. The enclosures were often a living fence made out of *raketasonjo* or sisal (*Agave* sp.) and thorny bushes was also commonly used. A ¼ ha area with *raketasonjo* was worth approx the value of a young zebu, ~400 000 MFr (around 50 €, December, 2003), and *raketambazaha* was worth the twice as much money when it is sold. If it is possible to take a harvest of raketa fruits from the plantation a farmer gets 20 000 MFr (around 2.50 €, December, 2003) for a zebu wagon (around 1.5 x 2 x 0.5 m) filled with raketa fruits. On the market four raketa fruits cost around 200-750 MFr (0.03-0.09 €, December, 2003)

In Beloha, the chief of the forest management communicated that areas of forest that had been converted to agriculture were usually abandoned after two to three years. When the fields are abandoned the authorities demand that the people replant the area with raketa. According to him, 2000 ha of converted forest areas were planted whit raketa every year in Firaisana Beloha. In Tranoroa one interviewed person related that in Besakoa there is a law saying that if a person cut down forest without permission for new agriculture fields, he is liable to replant this area with *raketasonjo*. The punishment is not so much the planting itself but the cost of cladodes for the plantation. One man that was cutting a forest area of 10 ha was commanded to plant 6000 plants. In Tranoroa in a former village some people had come together and planted an area with *raketanos*.

Raketabefatike was at some places planted as fences around agriculture fields both by itself but also together with old *raketasonjo* fences that have lost the cladodes near the ground.

Problems caused by raketa

Even if many of the raketas in southern Madagascar are useful, there are problems connected to the *Opuntia* spp. *Raketamena* is the most important species causing problems but also *raketanosy*, *raketambazaha*, *raketabefatike* and *raketakoake* were listed as causing problems.

Raketamena

Raketamena is the raketa that causes most problems for the people in southern Madagascar. The problems caused by this raketa can be summarised in that it is grows fast and in fact hard to get rid of. At the same time *raketamena* is not possible to use as fodder and the fruits do not taste good. All informants in the interviews agreed that *raketamena* is causing severe problems and that the area covered by *raketamena* must decrease. There were three main problems connected with *raketamena*:

- The weed problem. *Raketamena* is infesting the fields used for food production as well as the grazing areas for the Zebus and other livestock, reducing food production and lowering the capacity to feed the livestock. There is also a huge problem that

raketamena invades villages and roads and impedes peoples ability to travel and move without hindrance. *Raketamena* also seems to be a good competitor and is affecting other flora negatively.

- The loss in livestock. Zebus, goats and sheep do not usually eat *raketamena* but during the dry months, some of them are eating *raketamena* anyway. According to people at several study sites an animal that has eaten *raketamena* often die. The time it will take and the amount that kills an animal is varying, some people arguing that the animal will die in the same day and others that tell that the animal must eat *raketamena* on several occasions and it can take month before the animal dies.

- The health problem. When people eat *raketamena* fruits they get heavy diarrhoea. Almost everyone except a few people say that the spines of *raketamena* cause serious infections.

The weed problem

This problem varies with the total density of *raketamena* in the area. *Raketamena* have seeds and if a cladode is detached from the plant it can produce roots and create a new plant. In Barabay, Lavanono, Soamanitse, Cape St. Marie, and Marovato in almost every interview the problems with fields overgrown by *raketamena* was mentioned. Both in Lavanono and Soamanitse informants said that they need to migrate because of the increasing abundance of *raketamena* but they cannot do so because the land is their ancestors land and by that reason they can't leave it. When the question "is *raketamena* affecting other plants?" was asked all but two informants said that *raketamena* was affecting the grass and herbs negatively and many also said that *raketamena* even affected other raketas and tree species by decrease their growth and regeneration. In a group interview in Cape St. Marie a question was asked "what do you think about *raketamena* growing in the forests?" the answer was "all the forest we had before is already killed by *raketamena*".

The loss of livestock

The numbers of interviews where the problem with *raketamena* killing the livestock was mentioned fluctuated between the localities. Soamanitse, Cape St Marie and Ankilimasy were the localities where the problem was mentioned most times (Table 3).

Table 3. *The number of people (n) mentioning that the consumption of raketamena is killing the livestock, and the number in percent of all informants at the locality*

Location	n	%
Beloha	1	9
Barabay	5	50
Lavanono	2	25
Soamanitse	6	67
Cape St. Marie	3	60
Marovato	4	50
Ankilimasy	2	67
Antaranta	1	25

Many of the informants also gave examples of the amount of lost livestock. This value was varying between both the localities and people (Appendix IV) from the same locality but they all agreed that *raketamena* is highly decreasing the amount of livestock at the locality.

The health problem
There was no one among the 78 interviewed people that hade consumed *raketamena* fruits as food without having been forced to due to food scarcity. However, everyone could relate the problems that followed the consumption of *raketamena*. Some informants said that the fruits bad for adults but if children ate the *raketamena* fruits they would get strong. This, according to a doctor in Tsihombe is a misunderstanding, because they will only look strong according to the elevated water content in their bodies not that the children get strong. The infections caused by the spines are also a serious problem. To stop the infection it is necessary to open the infected wound and take out the spine edge according to some informants. There is also one indirect health problem caused by *raketamena*. When *raketamena* is very dense it is easy for rats to hide and they can spread disease among people.

Raketabefatike
Raketabefatike does not, according to the interviews have the aggressive growth of *raketamena*, but the spines and fruits cause the same problems as *raketamena* and this was seen as a problem. It was also said that zebus could die if they ate the raketa. *Raketabefatike* is in some study sites called *raketamahararake*.

Raketanosy and *raketambazaha*
The problem with these two raketas is connected to fruit consumption. According to several people in all villages, consumption of too many fruits of *raketanosy* and *raketambazaha* cause constipation. The amount of fruit possible to consume varies from ten to 25 fruits each day. According to some informants, more than 20 fruits a day cause constipation. But the fruits only cause problems when they are eaten in great numbers and without any other food. Many informants said that if the fruits are eaten with other food e.g. yogurt, mango, milk or cassava it is possible to eat more than 20 fruits of these two raketas without getting any stomach problems.

Raketakoake
This raketa was only present in Tsimilofo. *Raketakoake* are seen as a weed because the fruit does not taste good and it grows slowly. The people in Tsimilofo want to get rid of *raketakoake*.

Methods to control *Raketamena*
No person in the interview claimed that they had succeeded in eradicating *raketamena* from any large area. At some study sites, small areas have been cleared of *raketamena*. The commonly used method is to cut down the plants and burn the cladodes (Appendix III). This method does not work well since areas and plants not burned thoroughly enough will re-grow rapidly. In some areas all the *raketamena* plants were dug up and the plant parts were put in a hole in the ground and dried one month by the sun, then the hole was covered with a 20 cm layer of soil. According to several informants this method worked well to control of *raketamena*. The same method was used in Barabay, Lavanono and Cape st. Marie, and in Soamanitse and Marovato, but in Marovato the plants and roots were burned before they were buried.

Discussion

The introductions of raketas in southern Madagascar have been deliberately by people who have travelled to other areas and brought cladodes back to their home village, or trade between villages. The exception is *raketamena* which has rarely been deliberately planted. Lavanono and Soamanitse were identified as original sites of introduction of *raketamena* and this can be supported by the observation of its currently high density and abundance (Brolin, 2005) and that these sites had the earliest date of introduction among all sites.

Raketasonjo was ranked as the paramount *Opuntia* among the informants. This is probably due to the many benefits of this raketa. Although the spines must be burnt off, the fruits represent one of the most important food resources during several months. *Raketambazaha* was ranked high probably due to the absent of spines and can therefore be given to the livestock directly. *Raketakopake* is a raketa with useful parts but it is often in low densities and the fruits are not tasty as the fruits of *raketasonjo*. *Raketasonjo* and *raketambazaha* are really important resources in this dry area. The fodder is always present and the huge rate of mortality in cattle when the first raketa were killed in the late 1920s and early 1930s suggest the magnitude with which raketas is increasing the carrying capacity for cattle herds in this area.

Raketamena (*Opuntia stricta*) was the species people disliked most and the problems with this species can roughly be divided in three categories; 1) effects on vegetation, 2) social problems and 3) economical problems.

The biological problems are caused by the good competitive ability of *raketamena* and all informants except two agreed that *raketamena* affected the native flora which also is confirm by Brolin (2005) who studied the effects of *raketamena* on the flora during the same period as this study was performed. In these areas there is also an increasing problem with deforestation (Sussman et al. 1994) and the possible effect of *raketamena* decreasing tree growth and regeneration.

Raketamena is increasingly invading fields used for food production and this increases the risk of serious famine. There can also be an economical loss when *raketamena* is so dense that it is ousts useful raketas as *raketasonjo* and *raketambazaha*. Furthermore *raketamena* results in loss of livestock and zebus since animals may die after eating *raketamena*, as well as grazing areas becoming overgrown. If the grazing lands decrease the dependence of complementary fodder such as *raketasonjo* and *raketambazaha* will increases.

A program to eradicate raketamena from these areas is urgent and has to be done as soon as possible, however today cause of the lack of suitable food, many people is forced to use *raketamena* as a food resource. It is of highest importance to arrange an alternative food resource to compensation all these people who survival depend on the raketamena fruits.

Conclusion: suggestions for management

Manual eradication

Today the manual eradication is the only method used to decrees the amount of *raketamena*. Some of the methods are only short term solution (cutting the plant and dumping it in another place) and not actually decreasing the amount satisfactorily. When the survey was carried out in this area the United Nations funded a program (Programme Alimentaire Mondial) to cut down the plants, dig up the roots and burn and the bury all the plant parts. The local villagers did the work and were paid in kind with food. This is, so far, according to several people the best method used to decrease the *raketamena*. The method may be good but the amount of *raketamena* is so great that it needs thousands of working hours to decreas the stands to a non-threatening level. Also the program was only foundation work done inside the villages and along roads. This means that there is little eradication being done on pastures, fields or in the forest.

Biological control

In other countries such as Australia and South Africa, the problem with *Opuntia* overgrowing land areas has partly been solved by introducing biological controllers e.g. *Dactylopius* sp (Cochineal) and *Cactoblastis cactorum* (Cactus moth). What makes Madagascar different is the very great local economical dependence on *Opuntia* species. It is still possible that what happened in the early 20th century when cochineal was introduced could still happen again if, for example the cactus feeding moth *Cactoblastis cactorum* are introduced into Madagascar witheout accurate and careful management. Therefore a control program of *Opuntia stricta* based on a biological control management needs years of studies of the lifecycle and ecological performance of *Cactoblastis cactorum* in the natural environment in south Madagascar.

The problems with *Opuntia stricta* today are alarming and serious for the people living in Androy. The mechanical control today is the most realistic method to decrease areas covered with *Opuntia stricta*. The challenge of finding a method that controls *Opuntia stricta* but not jeopardize the other economical and social important *Opuntia* species is immense.

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Appendix I

Lokal Taxonomy of *Opuntia* spp.

Raketa name	Synonym	Tranoroa	Tsimilofo	Beloha	Barabay	Lavanono	Soamanitse	CSM	Marovato	Ankilimasy	Ataranta
Andambo	borivoa, kopake	X		X				X		X	
Be	Nosy		X								
Befatike	Mahararake			X	X	X	X	X			
Beravina							X				
besofy$_1$											X
besofy$_2$	Tsirembendambo									X	
Bevoanononggigy	Voanononggigy	X									
Bevolo										X	
Borivoa	kopake, andambo	X	X							X	
Drakake										X	X
Gasy		X	X	X	X	X	X	X	X	X	X
Kalibake										X	
Koake			X								
Kopake	borivoa, andambo	X	X	X	X		X	X	X		
Lavavoa		X									
Madam	mena**			X	X						
Madinike							X				
Mahararake	Befatky		X					X	X		X
Malam	milo, malamsomizo							X	X		
Malamsomizo	malam, milo								X		
Mbazaha		X	X	X	X	X	X	X	X	X	X
Mena	madam**	X	X	X	X	X	X	X	X	X	X
Milo	malam, malamsomizo					X		X	X		
Miritse										X	
Nosy	Be	X	X	X	X	X	X	X	X	X	X
Pekto										X	
Siro						X					
Somizo	sonjo*	X	X		X					X	
Sonjo	somizo*	X	X	X	X	X	X	X	X	X	X
Tsilo		X									
tsirembendambo										X	
Voanononggigy	Bevoanononggigy		X							X	
Number of raketa names		**12**	**12**	**9**	**9**	**8**	**9**	**11**	**10**	**16**	**8**

*, ** some but not all informants said that for him/her, this species was the same but with two names.

Appendix II

Introduction of *Raketas*

Raketamena

Tranoroa

In Tranoroa there are two stories relating the introduction of *raketamena*. The most frequent tells that *raketamena* was brought to Tranoroa by bird faeces coming from Beloha. The second one tells that *raketamena* was introduced in 1968 by a person that brought cladodes from a fence around a house belonging to a vet in Beloha. The reason for the introduction from Beloha to Tranoroa was that this raketa worked as a really good fence. The man that introduced *raketamena* to Tranoroa in 1968 told this story.

Tsimilofo

Persons in Tsimilofo told of only one way of introduction; birds. The bird that they think was responsible is *Corvus albus* (Pied Crow) named *Koake* in this region. Two people said that it was birds coming from Lavanono. The year of introduction was on the other hand more varied. *Raketamena* was introduced to Tsimilofo area before 1975 and after 1960 and one person thought that *raketamena* was introduced 30-40 years ago e.g. 1963-1973.

Beloha

Raketamena come to Beloha either by birds or by humans. The person who thought birds were responsible blamed birds from the African mainland for introducing *raketamena* in Beloha area. The other way of introduction could be by a *vazaha* (foreigner) some time before 1970 or 1968-69.But according to the information from Tranoroa, *raketamena* was present in Beloha before 1968.

Barabay

The introduction in Barabay was by birds was mentioned but the most common way of introduction was that people had brought cladodes from Lavanono. The years mentioned of introduction to Barabay were between 1972-1975 but one informant said that *raketamena* was present but uncommon in 1970.

Lavanono

In Lavanono was the introduction made by Maharongatse in 1959 or 1960. But in Soamanitse, people recounted that Jangazona or Antara was the first to plant *raketamena* in Lavanono and that he was doing this in 1957. No one in Lavanono recalled any other way of introduction than on purpose by humans.

Soamanitse

The informants in Soamanitse not only told the way of introduction to their area but also the origin of *raketamena* introduction to Madagascar. The narrated was as follows.

> In 1956 or 1957 a *vazaha* was living outside Soamanitse around 2 km east of Lavanono. He was in Madagascar to help control the problem with grasshoppers (dessert locusts). His name was Claudére and he came from the Reunions or Mauritius. Claudére gave some cladodes and/or fruits from *raketamena* to Antara, which planted in Soamanitse and Jangazona, which planted in Lavanono. Claudére told the people that this was a very good raketa; so good that where this raketa grows even an orphaned child could survive. According to Claudére they could eat the

fruits, the cladodes were good fodder for the livestock and the raketa as fast growing makes an excellent fence.

Some people still remember the ceremony from the occasion when Claudére gave away the cladodes and/or fruits.

Cape Saint Marie
The interviewed people in Cape St. Marie gave two stories of introduction.

1) In 1969 a woman named Marzet planted *raketamena* in her garden because she liked the taste of the fruits. People saw the plant and noted its fast growth and picked cladodes to plant on there own fields.

2) Earlier zebu owners travelled to the flat land around Lavanono to let their zebus graze. Some zebus ate the fruits from *raketamena* and seeds were spread to Cape St. Marie from Lavanono with the livestock faeces. The *raketamena* was in this way dispersed to Cape St. Marie around 1970.

Marovato
According to the people in Marovato *Raketamena* was introduced some time around 1967-72. According to one informant, *raketamena* was brought to Marovato on purpose by people but later on giving the year 1979 as the year of introduction.

Ankilimasy
Raketamena was introduced in Ankilimasy in the year 1979. The way of introduction was not known.

Antaranta
There are two possible years of introduction in Antaranta; 1983 or 1988. In both cases the explanation given is that it was birds and/or zebus that brought *raketamena* seeds into this area.

Raketasonjo

Tranoroa
Raketasonjo was most likely introduced in Tranoroa in 1964 and was brought on purpose by people from Beloha or Ambovombe. There was also one informant said that *raketasonjo* was introduced in Tranoroa in 1956 for the purpose of making rum from the fruits. The informant was unsure if this introduction was in the Tranoroa area or in a place in Farintany Tulear.

Tsimilofo
The introduction of *raketasonjo* in Tsimilofo took place sometime between 1960 and 1964. A man called Limbasa introduced the raketa from Marolinta.

Beloha
Two people may be responsible for the introduction of *raketasonjo* into Beloha area. The first is Limbasa (who died in 2000 in Beloha) and it was said that he brought it and made a

plantation in Beloha. He shared it with the people and taught them how to use the fruits and feed the livestock with the cladodes. The other person was Tanambiby and he brought *raketasonjo* from Ansidava south Marolinta. The year of introduction differs between the two scenarios. It was said that Tanambiby planted in the year 1958 and Limbasa in 1963. It is unclear which is the true story but most of the interviewed people gave the year of introduction between 1956 and 1959.

Barabay

The year of introduction in Barabay fluctuates very much. The earliest year is 1950 and the latest 1966. Four persons are named as the introducer of *raketasonjo* in Barabay; Forsé (introduced 40-50 years ago eg.1953-63 from the east), Tsiasitake (introduced 1966 from a area close to the Menarandra river), Mahatrea (introduced after 1956 and before 1970, the plant being brought from Marolinta) and an unnamed person who brought the plants from Bevoalavo in 1950-51). It was said that to start with a 50 hectare big area was planted with *raketasonjo,* and fenced with sisal, *Agave sisalana,* and guarded by people.

Lavanono

In Lavanono only two persons gave any year of introduction; 1953 from Marolinta and 1963, origin unknown.

Soamanitse

Raketsonjo was introduced in Soamanitse in the mid 1950's. Just like in Barabay, Mahatrea could have been the introducer and the origin of the raketa could have been Marolinta.

Cape Saint Marie

Raketasonjo was introduced to the Cape St. Marie area in 1961 by Miranga taking the *raketasonjo* from Marolinta.

Marovato

In Marovato *raketasonjo* was introduced to the area around 1968 or maybe 1971 from Ambalanosy.

Ankilimasy

Thee years are given for the introduction to Ankilimasy; 1961, 1968 and 1970. These years are given with the same origin of *raketasonjo;* from Beloha to Tsihombe and then taken from Tsihombe to Ankilimasy.

Antaranta

In Antaranta was *raketasonjo* introduced sometime between 1966 and 1969 or in the year 1964. The raketa were taken from Beloha.

Raketambazaha* and *Raketanosy

The introduction of *raketambazaha* to Madagascar as a whole is known but information about the spread to the villages and the countryside is scarce and very diverse. Only the interviews in Tranoroa, Barabay, Soamanitse, Marovato and Antaranta give a year of introduction in the area and these years vary with 50 years e.g. Tranoroa 1910-20, Barabay 1943, Soamanitse 1960 (coming from Tsihombe), Marovato 1930 and Antaranta 1937. In Tsimimilfo, Beloha, Lavanono and Ankilimasy the people could only answer that *raketambazaha* was introduced a

long time ago. In Antaranta one man talked about a big plantation of *raketambazaha* close to the village. According to this person every Firaisana had a big plantation of *raketambazaha* called *Toby*, which means a camp (compare with the introduction of *Raketasonjs* to Barabay). The authorities made the plantations and when the fruits were mature, a *Comander* called out all the *Chefcarty* (Chef of the Fukontany) to come and share the harvest between the different Fukontany in the Firaisana. This system worked in the Antaranta area for five or six years. It was forbidden for livestock to be inside this plantation and if any zebu or other domestic animal entered the *Toby* the owner was forced to pay a fine. The Toby close to Antaranta was around 200 hectares and situated in an area one kilometre from Antaranta called Ambarobe.

Information about the introduction of *raketanosy* is even scarcer. Only interviews in Tranoroa, Marovato and Antaranta gave any date of introduction. Oldest is the *raketanosy* in Tranoroa where it was introduced before 1909. In Antaranta *raketanosy* was introduced between 1942-47 and youngest is *raketanosy* in Marovato where it was introduced in 1980 from Tsihombe. The *raketanosy* in Soamanitse was brought from Ampanihy. In Ankilimasy the only date of introduction given was the answer "It came for very long time ago, before world war one".

Raketabefatike
The date of introduction of *raketabefatike* and *raketamaharake,* which is the same species hawing two names, is varying. In Marovato *raketabefatike* was seen for the first time already around 1977 originating from Bevaro and in Lavanono 1983. In Tranoroa and Antaranta this raketa was first seen in 1993 and in Barabay after 1970 maybe as late as 1996. The raketa was established in Antaranta by seeds.

Raketakopake
Raketakopake was present in almost all study sites but only in Tranoroa, Barabay and Marovato could a date for introduction be established. The raketa was brought to Tranoroa after 1964, Barabay in 1942 from Marolinta and *raketakopake* came to Marovato in 1977 from Soamanitse.

Raketamadam
In Beloha *raketamadam* was present before 1983 and was seen for the first time in Barabay in 1998.

Raketamalam
This raketa was introduced in Cape St. Marie around 1993. In Marovato there are many suggested years of introduction. The oldest is 1975-76 when it was brought from Tsihombe. The next is 1985 from Marolinta, 1981 from Amborongo and the latest, 1998, when brought from Tsihombe. There was also one informant that stated *raketamalamsomizo* was present in Marovato before 1943.

Appendix II

Raketaborivoa, Raketalavavoa, Raketa(be)voanonongigy, Raketakoake, Raketamilo* and *Raketadrakake

For many of the more unusual raketas there was very scarce information about the time of introduction to the different study sites. Below follows the introduction year for the unusual raketas.

Raketaborivoa: Tranoroa 1993 and Ankilimasy 1964.
Raketalavavoa: Tranoroa 1993.
Raketa(be)voanonongigy: Tranoroa 1974 and Ankilimasy around 1968.
Raketakoake: Tsimilofo 1972.
Raketamilo: Lavanono around 2000.
Raketadrakake: Ankilimasy around 1961-68 and Antaranta 1966 from Beraketa.

Appendix III

Perceived threats

Tranoroa
In Tranoroa three people suggesting that in five years time the problem with *raketamena* will be as big as in Beloha. One estimated that the problem will be bigger than in Beloha in 10 years time and maybe "very big" in ten or 20 years time.

Tsimilofo
The *raketamena* problem is going to be very big in Tsimilofo in five to 10-15 years, and the problem is as big as in Beloha in two to three years time.

Beloha
Raketamena has been a problem in Beloha for some years already. The number of years varies between seven and 20 years. Four people estimated that in five years the problem is as big as in Lavanono.

Barabay
The problem with *raketamena* was estimated to be very big in around ten years time. A village close to Barabay have been forced to move the whole village to a new area when the old location for the village was overgrown by *raketamena.*

Lavanono
The people in Lavanono have had a problem with *raketamena* for 20 years but three people related that for the last 10 years the problem has been growing very fast.

Soamanitse
As in Lavanono, *raketamena* has been a problem for 20 years especially during the last 10 years.

Cape St. Marie
For 20 years there has been a problem with *raketamena* here. In the park during the last ten years, the cower has increased from ⅛ of the park to ¼ today. One of the staff at the ANGAP office in Cape St. Marie estimated that in 20 years the park would be covered by 50% *raketamena*.

Marovato
In Marovato there has been a problem with *raketamena* for eight to twelve years and during the last two to four years, the problem has increased to the size of problem in Lavanono.

Ankilimasy
The problem in Ankilimasy is estimated to increase to the size of the problem in Marovato in three to five years time. In Ankilimasy they already have problems with *raketamena* during the last two to five years. *Raketamena* started to invade fields two years ago.

Antaranta
Raketamena has been a problem for four to five years. One person guessed that in two years the problem would be as big as it is in Faux-cap and Lavanono.

Appendix IV

Impact of Raketamena on the Livestock

In Tranoroa there was only one person who mentioned anything about the damage *raketamena* caused to the livestock. She said that if a zebu ate *raketamena* it would get sick. There were no other persons mentioning anything about *raketamena* making the zebus sick. However in Beloha there were four people talking along these liner. Three said that the stomach swells on a zebu after eating *raketamena* and that *raketamena* makes the zebu sick. The fourth one was said that you have to keep an eye on your zebus so they don't eat *raketamena* because if the zebu eats *raketamena* it will die. In Barabay five people said that *raketamena* harms or kill zebus that have eaten *raketamena.* According to one person there are 1000 zebus in the fukuntany and 300 zebus die every year from *raketamena.* There was one other interviewed person who said that during the last ten years 200-300 zebus have died due to *raketamena* and another said 40 zebus had died during the last 3 years. In Lavanono two people said that *raketamena* is killing zebus. According to one person, a zebu stomach swells after eating *raketamena* just like if the zebu had drunk seawater. One person said that before *raketamena* this fukuntany had 6000 zebus but now they only have around 200. In Soamanitse there were several people saying that *raketamena* is killing the livestock. One said that 20 years ago he had 70 zebus and 1000 goats and sheep, but now he only has 8 zebus and no goats or sheep, and another had 200 zebus, 20 years ago and now was he only had 40 left. There was also one that had 70 zebus ten years ago and in six years all died and for the last four years he haven't had any zebus. In Cape St. Marie were there two zebus dying every week due to *raketamena.* Before *raketamena* existed a person had few zebus if he/she had 100 zebus and many if he/she had 1000 zebus. Now a person having 40 zebus has many. In a group interview in Cape St. Marie they said that goats and sheep were the first animals to die when consuming *raketamena.* Even now several goats and sheep die when *raketamena* flowers because the livestock eats the flowers which according to the people are poisonous. There were four people in Marovato relating that *raketamena* is killing the livestock. One mentioned that 400 zebus die every year in the fukntany and another said that 15 years ago he had 10 zebus but during the last two years three zebus have died each year and now he didn't have any zebus any more. In Ankilimasy village 15 zebus have died because of *raketamena* and in the fukuntany that has 200-250 zebus, 30 dies every year from consuming *raketamena.* In Antaranta one person said that during the last ten years four zebus had died due to *raketamena.*