Smallholder zebu and forage production development in central Madagascar

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Key words: *Brachiaria sp*; *Bos indicus*; livestock; native grasses; Sorghum

Abstract. Poverty in the Central Highlands of Madagascar is partly driven by inefficient exploitation of native forages and poor livestock nutrition. Zebus are of importance as cultural symbols, but this tradition has grown disconnected from agricultural policy. This project is working with three central highland communities near the protected areas of Itremo, Ibity and Ankafobe, to boost rangeland productivity and trial management methods which will support key forage grasses and improve livestock nutrition. A severe nitrogen deficiency compounded by extremely acidic soil conditions and low phosphorus is observed across the three sites. The lowest grazing capacity of an estimated 0.7 livestock unit per hectare and biomass production of 1600 kg/ha is observed at Ankafobe, the highest elevation windy site with fires that are almost annual. Low production is due to acidic soils with a lack of phosphorus as well as likely iron toxicity. The project works with 90 households owning a total 150 female zebu, 1-5 per household. The project initiated 3 demonstration farms to show the planting of sorghum for silage, harvesting of the native grasses for hay, and building a secure barn meeting at least minimum animal care standards, using local materials to protect the livestock from the weather and theft which is sadly perceived to be common. In the first year the project produced the highest yields in the most remote and fertile site of Itremo, with 365 kg of sorghum silage from 0.5 ha and 165 kg of Brachiaria hay from 0.5 ha. Five households based in the milk producing region of eastern Ibity have completed new barns. Fifty percent of households at Ibity successfully fed silage and hay to their zebu for the first time. Madagascar remains famous for subsistence farming and rural poverty with a long-term decline in livestock, but substantial opportunity nevertheless exists for integrated crop and livestock production, alongside the protection of biodiversity in nearby forests.

Introduction

Feed plays a critical economic role in livestock production and has a strong influence on the weight, reproduction, and health performance of livestock such as cattle. Feed must be controlled to have highly productive livestock (Andriarimalala, 2021). However, in Madagascar, its natural pastures, which cover more than half of its surface, are often the only source of food for all ruminants. And with population pressure, the restriction of grazing areas, the expansion of crops and the burning of natural pastures almost every year, the herders are faced with persistent problems (Rasambainarivo 1997 and Razafinarivo 2018). This situation has plunged cattle farming into a crisis of chronic undernourishment and vulnerability to disease. Further aggravated by zebu theft and diseases, the cattle herds in Madagascar, especially the local breeds, are in a critical situation, having fallen from 23 million in the early 1980 s to around 6 million today with diversity becoming dangerously low (IFC 2018). The availability and accessibility of food resources are increasingly challenging. For this reason, many projects are trying to improve cattle production in Madagascar by relying on the development of forage production. We present the results of our project's intervention in the first year of implementation on improving zebu nutrition using native grasses and selected fodder crops, as well as identifying barriers that the project needs to address to achieve its objectives.

Methods

The project works with communities living around three Protected Areas in the central highlands of Madagascar (Ankafobe, Ibity and Itremo) who have developed trusting relationships with international scientists for over 20 years. Ankafobe is located on the highlands of Ankazobe, 132 km northwest of Antananarivo. The climate in the Ankafobe is represented by a wet season (October-March) and a dry season (April-September). The total annual rainfall is 1671 mm (MBG, 2019). Ibity belongs to the Vakinankaratra

region, in the central part of Madagascar, and is located 25 km south of Antsirabe. It should be noted that this region is home to both the largest dairies in the country and many small mixed crop-livestock farms, some of which are oriented towards dairy production based on fodder crops and associated with rice production (Penot et al., 2016). Itremo is located 200 km southwest of Ibity and 35 km west of Ambatofinandrahana, ranging from 1400 m to 1923 m elevation. The climates of the Ibity and Itremo regions are characteristic of tropical highlands. Average annual rainfall is 1583 mm at Ibity and 1416 mm at Itremo (Alvarado 2012).

The project is based on the principle that farmers will learn by implementing the methods they observe on the demonstration site, to ensure that techniques appropriate to the local context are passed on. In this case, in each site:

- The project works with 30 zebu female (the local breed is called ‘’Omby gasy’’) owning households to initiate pilot activities in their respective villages. On average, the herd size is between 1 and 5 Omby gasy females per household.
- The project has set up a demonstration farm with 4 Omby gasy females for practical use in monitoring milk production, body condition scoring, calving rate, grazing effect in the experimental pasture and all other farm activities.
- The barn was built on the simplest model to be replicated by communities and constructed with locally available materials.
- 2ha of experimental pasture fenced, of which 1ha is protected from fire and 1ha is burnt for the comparison of grass species diversity and frequency, the grazing management using project cows to record the fire effect on biomass production.
- The project has a 1ha field for planting other fodder crops such as *Sorghum sp* and *Brachiaria brizantha.*
- The project has valorised the available crop residues for storage and further use.

Results and Discussion

Forage production and grazing capacity

To demonstrate the cultivation techniques to the beneficiaries, the project grew a local variety of sorghum (food sorghum) and *Brachiaria brizantha* at the demonstration site. The details of the crop and the yield obtained in the 3 sites (Ank: Ankafobe, Ibt: Ibity, and Itr: Itremo) are summarised in the following table.

Table 1: Details of the forage production in the demonstration farm

	Cultivated area (Ha)			Seeds cultivated (kg)			Production/storage (kg)			Plantation period	
	Ank	Ibt	Itr	Ank	Ibt	Itr	Ank	Ibt	Itr	Seeding	Harvesting
Sorghum sp. (for silage)	1	1	0.5	7	6	4	22	230	**365**	February	May
B.brizantha (for hay)	1	1	0.5	5	8	4	0	110	**165**	February	June
Native grasses (for hay)			-	-	-	-	-	115	-	-	April
Rice straw (Storage)			-	-	-	-	1000	800	600	-	June

Beneficiary households in Ibity had the opportunity to participate in a training session on hay making. They were also able to grow sorghum of the same variety as that grown by the project. Each beneficiary household received approximately 250 g of *Sorghum sp.* Fifty per cent of them have successfully fed silage and hay to their zebu for the first time. They have stored 150 kg of hay during the wet season and made 120 kg of silage using this sorghum species. They started feeding silage and native grass hay to their cows since the beginning of the dry season in June 2022. This was the first year of the project and it was planned to plant sorghum only for the project demonstration field. However, three beneficiaries in Ankafobe attempted to grow sorghum, but the seeds did not germinate. This might be due to either the delay in planting the seeds (February instead of December or January) or the quality of the soil, or the unusual rainfall pattern which was different to Ibity and Itremo.

According to the calculation of the experimental pasture grazing capacity by the herbaceous survey step-point method introduced by University of Pretoria (Truter and Venter 2017), one zebu needs 1.2 to 1.4 ha per year

for its complete nutritional needs. Biomass production in the project sites is calculated to be between 1600 and 6100 kg per ha depending on the fire regime.

Milk production

The project's livestock technicians regularly visit the beneficiaries not only to assist them but also to collect data. The data is collected using the KoboCollect and individual monitoring sheets filled in daily by the farmers and collected weekly by the project technicians. The following figure shows the change of milk production of beneficiary households between May and July 2022, collected in Ibity, which uses silage and hay, and in Ankafobe and Itremo, which fed their cows only through grazing.

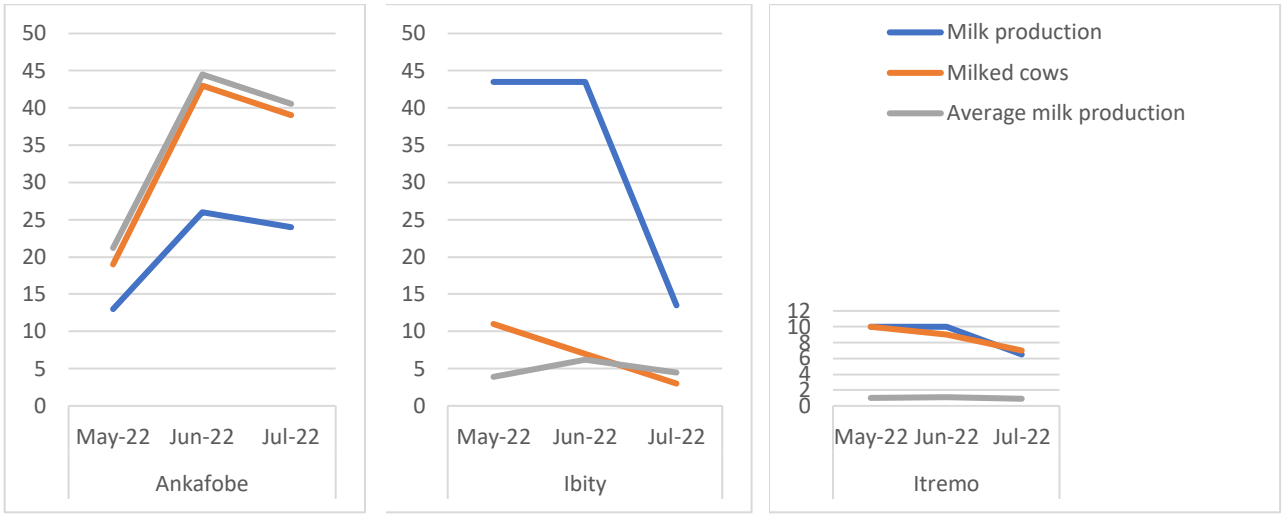
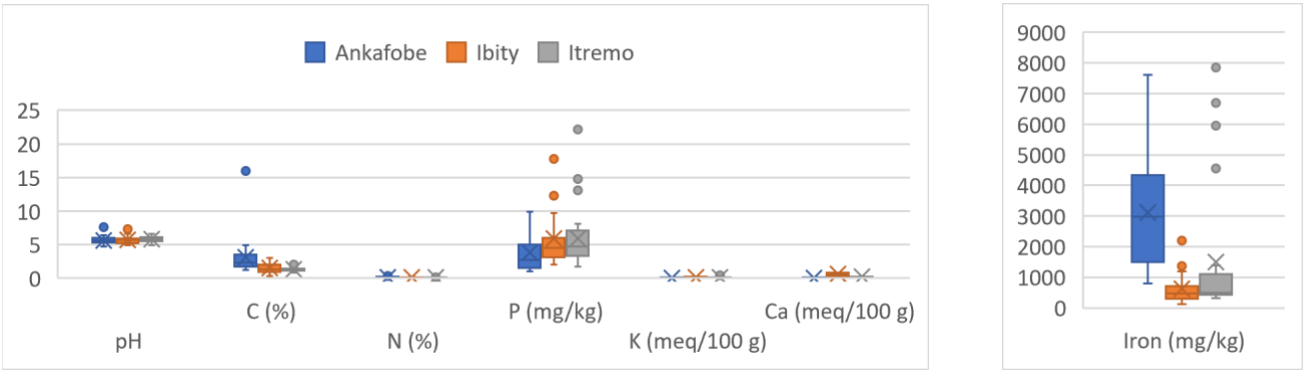


Figure 1:Evolution of milk production (in litres) of beneficiary households by site through the time between May and July 2022.

In Ankafobe, there are many milked cows compare to other sites, which explains the high milk production. After feeding the cows in Ibity silage and hay, the average milk production is increases even if the number of cows milked decreases. The low production in Itremo compared to the other sites could be explained by the fact that their tradition does not allow them to sell milk and therefore they do not milk their cows. According to Granier and Bigot (1971), the possibility of producing forages such as sorghum is of considerable importance to increase productivity, as can be seen in the milk producing region of Ibity.

Soil analysis

Seventy-three soil samples were collected from beneficiary and project sorghum fields, project experimental pastures, and beneficiary communal pastures located in the three project sites. Soil analysis from beneficiary and project sorghum fields is intended to provide information on soil properties in order to make appropriate corrections before sorghum cultivation. Soil analysis from communal pasture and the project experimental pasture aims to provide knowledge on the edaphic factors influencing the grassland diversity and its community. Sampling was carried out to maximise the range of, grassland community, and soil type. As soil analysis is expensive in Madagascar, the fields located close to each other represent a single sample. The result of the soil analysis is summarised in the following figure. The analysis methods are BRAY II for phosphorus, Kjeldahl for nitrogen, and glass electrode for pH.



2A 2B

Figure 2: Comparative soil analysis between project sites H, Carbon, Nitrogen, Phosphorus, Potassium and Calcium (2A) and for Iron (2B)

Figure 2 shows that most of the analysed samples have high to medium acidity, especially in Ankafobe. In all sites, the analysed samples have very low levels of nitrogen, phosphorus, potassium, and calcium. All sites have high iron toxicity, especially in Ankafobe. According to this result, this poor soil quality affects the floristic and nutritional composition of the pastures, and likely results in soil erosion. The forage grasses that grow there are also likely to have a low nutritional value such as the endemic *Aristida tenuissima*, *Aristida rufescens*, *Aristida similis*, and *Loudetia simplex* (Rasambainarivo, 1997).

Beneficiary perception of project activities in Ibity

After seeing the project activities on the demonstration farm, the beneficiaries at Ibity, known locally as 'Farmer Leaders', are enthusiastic and have replicated the project activities on their private farms. Five of them have finished building a new barn similar to the model constructed on the demonstration farm. Fifteen of them have made hay and made silage from sorghum. Thanks to these new fodder production techniques, Ibity beneficiaries are motivated to continue to be more ambitious in milk production. This is evidenced by the improvement of the barns, the storage of hay and the sorghum plantation. The following photos illustrate the activities reproduced by the beneficiaries.

Figure 3: New barn built by the beneficiary using locally available materials.

Figure 4: Native grass hay stored by the beneficiaries.

Figure 5: Sorghum plantation by a beneficiary in Ibity

Figure 6: Improved body condition of a cow fed with hay in September 2022

Conclusions

Contributing to the reduction of rural poverty in Madagascar through the development of cattle farming, especially in terms of feeding, is quite feasible. Grazing management, using native grasses and, where possible, the management of grazing fires are some of the best ways to achieve this, although it has its challenges. The use of other high-nutrient, climate-tolerant, soil-covering forage species, such as sorghum, is highly recommended to quickly supplement feed deficits from native grasses. The best approach to improve soil quality is to educate farmers to use their zebu manure to make compost and use it for their crops. These actions, which are new to the community, will contribute to the protection of biodiversity around the Protected Areas

by reducing poverty as well as reducing fire risk. Developing partnerships with two ministries of environment and agriculture, as this project does, could facilitate achievement.

Acknowledgements

Our warm thanks to the Darwin Initiative and the UK government for funding the project, to the Missouri Botanical Garden for their support in carrying out the project activities, the University of Pretoria for technical support on the forage production and soil analysis, to the Royal Botanic Garden Edinburgh for support on the fire ecology aspect of the project, Ministry of Agriculture (MINAE) and Ministry of the Environment (MEDD) for their support and authorisation for the various collection permits, and the National Center for Applied Research on Rural Development (FOFIFA) for soil analysis, and to the local communities and authorities for their help in the realization of the project and for its success.

References

Alvarado, S.T. 2012. Study area. In : *Evaluation du rôle des feux de brousse sur la composition, la structure, la phénologie, et la résistance de la végétation des bois de tapia (Uapaca bojeri) du massif d'Ibity, Nouvelle Aire Protégée, en vue de sa gestion durable.* Alvarado, S.T (eds). D Thesis, Université d'Avignon et des Pays de Vaucluse, pp.60-61

Andriarimalala, H.J. 2021. Estimation de l'ingestion et de la composition du régime alimentaire des ruminants à Madagascar, en utilisant les techniques des marqueurs et la spectrométrie dans le proche infrarouge fécale. D Thesis. École Supérieure des Sciences Agronomiques, University of Antananarivo, 158p

Granier, P. and Bigot, A. 1971. La culture des sorghos fourragers â Madagascar - Utilisation à contre-saison. Rev. Elev. Méd. Vét,. Pays trop., 1971, 24 (1): 125-36

Penot E et al. 2016. Adaptability of dairy farms in the highlands of the Vakinankaratra province of Madagascar : Impacts of the 2009 crisis. Rev. Elev. Med. Vet. Pays Trop., 69 (1): 19-31

Rasambainarivo, J.H. 1997. Pratiques agropastorales in Bilan et évaluation des travaux et réalisations en matière de conservations des sols à Madagascar. 1996.FOFIFA, DRRV.441-460

Razafinoro, T.D. 2018. Elaboration d'une méthode de suivi et de gestion des ressources pastorales par une approche combinée de modélisation et de télédétection. D Thesis. École Supérieure des Sciences Agronomiques, University of Antananarivo, 155p

Truter, W and Venter, D. 2017. Veld condition assessment Example. University of Pretoria.