Policy Brief for 10-106LIFE

Executive summary

We are providing new knowledge of the efficient pollinators of two important species of fruit trees in Burkina Faso, and this knowledge can be very important in terms of optimising fruit set.

<u>*P. biglobosa*</u>

- *P. biglobosa* depends on animal pollinators
- *P. biglobosa* is pollen-limited (even in the wetter site)
- Honey bees can compensate bat-pollination (both sites)
- If the climate becomes too dry (2012, northern site) many of the pollinated flowers abort as small fruits

<u>*V. paradoxa*</u>

- *V. paradoxa* depends on animal pollinators
- Stingless bees and solitary bees can partly compensate honey bee-pollination in terms of fruit set
- Flowers pollinated by stingless bees and solitary bees resulted in fruits with the same seed weight and germination time as the honey bee-pollinated flowers
- Fruit set in the open treatment was positively correlated with the number of honey bee colonies within 900-1,000 m from the given tree
- Fruit set in the semi-open treatment was positively correlated with presence of stingless bee colonies in the trunk of the tree.

Introduction

The objective of this PhD proposal was to study the impacts of climate changes on the fruit production of *Parkia biglobosa* (African locust bean) and *Vitellaria paradoxa* ssp. *paradoxa* (Shea nut tree) in Burkina Faso. Both species are traditional multipurpose parkland species enjoying great popularity among the rural population. In addition to their services within agroforestry (e.g. recycling nutrients), these trees produce edible fruits with highly prized seeds. Neither species have been domesticated although breeding programs have been started in their very early phase, and the important income and food supply from the species therefore depend on fruit-set and collection from wild trees. A key area where knowledge is incomplete is the pollination biology and its likely influence from the climatic conditions. The reproductive success is important, because it is the reproductive parts of the trees that are in high demand. In a dryer climate the amount of pollinators may drop due to less water and less food (i.e. nectar, pollen and fruits), and decreased density of the trees may challenge the pollination systems in the area. The present PhD project has therefore studied the interaction between climate and pollination systems, and tested options for increasing production and improved fruit quality by employing an integrated pollinator-management. The prospect is development of management practices that can mitigate the negative effects of climate change on fruit production of *P. biglobosa* and *V. paradoxa* in West Africa.

Main objectives:

1) To study how the drier climate in north of Burkina Faso influence the pollination of *P. biglobosa* and *V. paradoxa* compared with the pollination in the south of Burkina Faso, and relate results to the amount and number of species of pollinators and the optimum pollination requirements of the two species.
2) To test if pro-active pollinator management can increase pollination efficiency, and if this can lead to improved production of fruits and seeds of *P. biglobosa* and *V. paradoxa* in the parklands.

3) To study if the amount of pollen and/or degree of cross-pollination influence the amount and composition of the oil content of shea nuts (*V. paradoxa*).
4) To analyse to what extent pollination efficiency (amount and/or degree of cross-pollination) influence the germination capabilities and the protein content of seeds of *P. biglobosa*.

Background
This study is made in cooperation with Centre National de Semences Forestières (CNSF) in Burkina Faso. There has been a long cooperation between University of Copenhagen (IGN) and CNSF concerning many species including *P. biglobosa* and *V. paradoxa*.

<u>Climate change</u>
In order to study the impact of different climates, we chose two different study sites. Tiba & Gam (neighbouring villages) are in the centre of Burkina Faso, and hereafter called the 'northern site' compared to Pinyiri which is in the southern part of Burkina Faso and called the 'southern site'. Tiba & Gam are in the Sudano-Sahelian climatic zone with mean annual precipitation between 500-900 mm, and Pinyiri is in the Sudanian climatic zone with average precipitation between 900-1,100 mm (FAO 2006). In the northern rim of the distribution area of *P. biglobosa* bats are limited in numbers or even absent and honey bees are assumed to be the main pollinators. Since *P. biglobosa* is known to be bat-pollinated we wanted to study the pollination situation without bats. However, it was not possible to find a study site with both enough trees and no bats. Tiba & Gam were chosen because this place had a very small colony of bats (about 10 individuals) and a strong beekeeping community. Pinyiri in the southern part had both plenty of honey bee colonies and a strong colony of bats (numbering more than 1,000 individuals).

We wanted also to study the climate effect on *V. paradoxa* and Tiba & Gam had plenty of these fruit trees, but since the two study species were peaking at the same time it was not possible to do both species at the same time, and since *V. paradoxa* is not bat-pollinated this species was studied only in Pinyiri.

<u>Effect of distance to bee colonies</u>
We took the GPS coordinates of colonies of honey bees and some of the stingless bees (difficult to find) and used these to see if we could find a correlation between number of colonies within a given distance from a mother tree and the resulting fruit set in the treatments allowing access to the given bee species.

<u>*P. biglobosa*</u>
In 2011 we tried to separate the different groups of pollinators due to their different time of flower visiting in *P. biglobosa*, but it proved to be more than difficult because the bats were active from dusk to dawn, and when they left the honey bees arrived in huge numbers. We tried to change the arrangements of bags (some should hinder access during the night and others during the morning) before the bees arrived but due to the darkness and the tall trees it was not practical. In 2012, we used bags with different mesh size in order to exclude different groups of pollinators due to their size (open, semi-open 1 (access to honey bees and smaller), semi-open 2 (access to stingless bees and smaller), closed). These exclusion trials were coupled with observations of the flowers and potential pollinators. We did also perform controlled pollination (cross, self, and mix). We harvested the resulting fruits from all trials and analysed them for their weight and size. The majority of *P. biglobosa* fruits were also analysed for seed content and the mother-trees, the offspring (fruits), and the potential donor trees (father-trees) in the two study sites were genotyped and the donor trees assigned to the offspring. In order to do this the project had microsatellites developed by GenoScreen (Lille, France), which are now available to the research community. In order to study the effect of self-pollination versus cross-pollination we studied a subset of the fruits for their carbohydrate content in the fruit pulp and

protein content of the seeds, and performed a germination test, and let the seedlings grow for around seven months.

V. paradoxa

For *V. paradoxa* we employed an exclusion trial in both 2011 and 2012 in Pinyiri. We wanted to study the effect of the small stingless bees living in the trunks of *V. paradoxa* trees. The treatments were open, semi-open (access to stingless bees and smaller), and closed. These exclusion trials were both years coupled with observations of the potential pollinators. In 2012, we did also perform a controlled pollination trial (cross, self, mix), but we had difficulties in timing the availability of mature pollen and receptive stigmas, probably because 2012 was a year with low intensity of flowering and fruiting of *V. paradoxa*. The seeds were germinated both years, in 2011 in Denmark and in 2012 in Burkina Faso. However, both years the germination percentage was low. Since the controlled pollination trial failed we did not have the seeds for the oil content analysis.

Results

P. biglobosa

As mentioned above a number of microsatellites (eleven) for *P. biglobosa* was developed and described in a published primer note. This will make future research within the population genetic structure of *P. biglobosa* much more feasible.

For *P. biglobosa* we found several differences between the two study sites: The trees in the drier climate (northern site) had a lower tree density (0.3 trees/ha) and a higher percentage of self-pollinated fruits (28%) compared with the wetter climate (southern site) with 1.2 trees/ha and 5% self-pollinated fruits. We did see the same pollinators at both sites but fewer bats and only very few small bees (e.g. stingless bees) in the drier climate (northern site). These observations were reflected in the results from the exclusion trial with only 2% fertilisation for the semi-open 2 treatment accessible to small bees in the drier site compared with 22% fertilisation for the same treatment in the wetter site. The difference in bat numbers were not reflected in the fertilisation for the open treatment (83% in the dried site versus 88% in the wetter site) but the mean transport of pollen (distance between mother-tree and assigned pollen donor) was significantly higher in the open treatment in the wetter site whereas the open and semi-open 1 treatment statistically had the same distance in the drier site. From the flower observations we found that the main pollinators were different species of bats, honey bees, and different species of smaller sized bees; stingless bees (*Hypotrigona* sp. 1 and *Hypotrigona* sp. 2), allodapine bees (*Compsomelissa borneri*), and sweat bees (*Lipotriches* sp.). We did not find a correlation between number of honey bee colonies within a given distance and the fruit set.

We compared the early fruit set with the mature fruit set and found that the abortion rate was significantly higher in the drier study site. In the drier site the fertilisation went from 83% to 51% in the open treatment, whereas the fertilisation went from 88% to 80% in the same treatment in the wetter site.

The genetic variation in *P. biglobosa* is high within individuals but low between regions. We wanted to see if the honey bee pollinated flowers (incl. other smaller bee species, semi-open 1) had a lower genetic diversity than the open pollinated flowers (incl. bats), but the differences were very small at each site.

The controlled pollination trial showed that when *P. biglobosa* was hand-pollinated (with cross-pollen) the fruit set was significantly higher than the natural fruit set, implying that this species was pollen limited in the wetter site where the trial took place. Furthermore, the study showed that some of the trees were incompatible and the resulting fruit set was as low as the self-pollination.

The germination test showed that the self-pollinated seeds could germinate but they had a generally lower seed weight and the seedlings grew significantly slower than the cross-pollinated seeds. We found a trend of more carbohydrate in the fruit pulp in the cross-pollinated fruits compared with the self-pollinated seeds, but we found no difference concerning the protein content of seeds.

V. paradoxa

We found a clear need of animal pollinators to ensure significant fruit set. Honey bees were acknowledged being the main pollinators. The semi-open treatment allowing access to small bees showed that different species of stingless bees (*Hypotrigona* sp. 1, *Hypotrigona* sp. 2, *Liotrigona* cf. *bottegoi*) and the solitary bee (*Compsomelissa borneri*) could partly compensate honey bees, but the fruit set was reduced. We found no difference in seed weight or germination time between the open treatment (access to flowers for all visitors) and the semi-open treatment (access for small bees).

We found significant positive correlation between the early fruit set and the number of honey bee colonies within radius of 900-1,000 m. We did also find a significant positive correlation between presence of colonies of stingless bees in the trunk of the tree and both the early fruit set and the number of mature fruits per inflorescence. Only trees older than about 70 years (estimated by the villagers) had colonies of stingless bees in their trunk.

Conclusions

The pollinators are important for the fruit set, except in too dry areas where the abortion rates are high. Since honey bees and also stingless bees are manageable the number of colonies should be increased and/or the farmers should strive towards a pollinator-friendly environment (i.e. saving tall trees and natural nests, avoiding side-effects of pesticides, and providing water for the bees).

Implications

The results point to a greater awareness of the dependency on animal pollinators for the fruit set of the two studied species.

Recommendations

We recommend a greater focus on the pollinators. We have shown that *P. biglobosa* is pollen limited and that the fruit set of *V. paradoxa* was very low when the honey bee pollination was reduced. Therefore we recommend an integrated pollinator management with local beekeeping and a pollinator friendly environment. In the neighbouring country Ghana, meliponiculture (i.e. beekeeping with stingless bees), is developing. Hives for stingless bees have been developed and thereby it is possible to harvest their honey without destroying the colonies (Aidoo et al. 2011). We recommend further that the number of honey bee colonies should be increased. We saw a number of empty hives and it is possible that providing water for the honey bees would diminish the natural migration during the dry season (B. Svensson 2015, pers. comm., 5 May) before the flowering of e.g. shea, or as suggested by Sawadogo and Guinko (2001) by feeding the honey bees syrup to prevent their natural migration.

References

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