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Assessment of knowledge of Shea nut tree (*Viterallia paradoxa*) stakeholders (Shea nut collectors, processors and exporters) in pollination, Shea pollinators, their roles and the need for their conservation in the Northern region of Ghana

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Abstract
A descriptive study was carried out in the Northern region of Ghana to examine the knowledge of stakeholders of Shea nut/butter production(collectors, processors and exporters) in pollination, awareness of Shea pollinators, their roles and the need to conserve them. Ten districts and two communities from each of the districts were randomly selected from the 26 districts of the Northern region of Ghana for survey. Thirty collectors and thirty processors were randomly selected from each community, making 60 collectors and 60 processors per district. Ten exporters were also sampled from the exporters in Tamale. Three separate structured questionnaires were used to collect data. Collectors (92.7%) and processors (94.5%) were predominantly females whilst 60% of exporters were males. Most collectors were below 30years whilst processors and exporters were above 30years and married. Majority of collectors (83.3%), processors (80.6%) and 40% of exporters have no formal education. There was a significant relationship between educational level and knowledge in pollination (X^2 = 38.8; d.f. = 6; P< 0.00). Most of the respondents have large household sizes. The respondents (collectors (79.3%), processors (65.2%) and exporters (50.0%) have little knowledge in pollination and poor awareness of Shea pollination. From the study it was concluded that Shea collectors, processors and exporter have very little knowledge in pollination and awareness of Shea pollinators. Education on the importance of Shea pollinators and activities which favour their abundance on Shea trees is recommended to Shea production stakeholders.

Keywords: Pollination, Shea pollinators, Indigenous knowledge

Introduction
Shea tree *(Viterallia paradoxa)* in international and local companies have fostered the development of the country's Shea nut industry; consequently, Ghana has becomes one of the largest exporters of Shea nuts worldwide (Laube, 2015) [22]. It is estimated that about 9.4 million Shea trees abound in Ghana and these can potentially yield 100,000 tons of Shea nuts worth about 100 million US dollars per year (Hatskevich, Jenicek, & Darkwah, 2011) [17].
It covering land area of the country, occurring over almost the entire area of Northern Ghana covering land area of 77670 square kilometers with a sparse Shea tree cover in Brong-Ahafo, Ashanti, Eastern and Volta regions of the country (Hatskevich, Jenicek, & Darkwah, 2011) [17]. The Shea plant is widely known, valued and exploited by the local people in all the area where it occurs making it important both locally and internationally because of its multiple uses (Laube, 2015) [22]. The butter extracted from the nuts is the main economic product of the Shea tree. In Burkina Faso, it is referred to as women's gold (Pouliot, 2012) [29]. The monetary value derived from the Shea butter in Ghana and Cote d'Ivoire, has made the Shea tree an economic crop (Aguirre-Dugua *et al*., 2013) [3]. The Shea fruits are rich source of sugars, protein, calcium, and potassium during the "hungry season", when food stores run low (Naughton, 2016; De Leeuw, *et al*.2014).The trunk, bark and cortex, the roots leave are all used for the preparation of many traditional medicinal remedies for protection of the skin against harsh weather, wound healing, cure of superficial skin irritation and sore muscles (Egbewole, *et al*., 2015) [11]. These uses have also been recognized by nutritional chemists and pharmacologist in Europe, where it is used as valuable addition to moisturizers, cream shampoos and soap. The tree is also much sought after for placing hives in local beekeeping (ICRAF, 2013) [18]

The need to find substitute for cocoa in the confectionery and butter industries in the early 1970s ((Aguirre-Dugua *et al*., 2013) [3], made the Shea tree even more significant in Ghana, placing a high demand on the fruits from which the butter is obtained. The attempt to exploit its economic potential to reduce poverty in the northern region of Ghana and to make it contribute to Ghana's economy has attracted support and interventions from partner, non-governmental organizations (NGOs) and Government.

Pollination is the ecosystem process of transferring pollen grains from anther to stigma of flowers of the same plant species leading to fertilization (Scheper *et al.*, 2013) [31]. It is an important process in seed and fruit formation, making it a critical determinant in increasing food production and income of farmers. Animal pollination is one of the important services provided by ecosystems to humankind (Mitchell, Bennett and Gonzalez, Bommarco, Kleijn & Potts, 2013) [31]. Animal pollinators are responsible for the sexual reproduction of more than 80% of terrestrial vascular plants including most crop species (Grime, *et al*., 2014 ; Cronk and Fuller, 2014) [15, 9].

Current reports suggest that insect pollinators, both wild and domesticated, are on the decline in many regions of the globe resulting in a reduction in seed and fruit set, deformed fruits and seeds as well as reduced viability and germination of seeds (Potts *et al.*, 2010) [28]. Habitat loss, fragmentation and degradation, pesticides, invasive species parasites and disease and climatic change are major causes for pollinator decline (Potts, *et al*., 2016; Goulson, *et al*., 2015) [27, 14]. The Shea tree is pollinator- dependent (Kwapong, 2011; Campbell, *et al*., 2017; Russo *et al*., 2016) [21, 7, 30] with little evidence of self-pollination. Shea fruit- set is also limited by pollination (Okullo *et al.*, 2013) and so without external agents' pollination, consequent fertilization and fruiting will not take place.

The role played by pollinators unfortunately is not widely acknowledged, reducing the efforts of the public and policy makers to conserve this essential resource and ecosystem service (Lyver *et al.*, 2015). Assessing the local people's knowledge in particular, that of stakeholders of the Shea industry on their knowledge in pollination and the importance of Shea pollinators may be a prerequisite to reduce the decline in the population of insect pollinators.

A study conducted in Uganda indicated that more than 90% of interviewed farmers were not aware of the role played by bees in coffee yield increase (Munyuli, 2011). Further results of studies from Abro (2012) [1] revealed that the level of knowledge about biodiversity conservation, pollination and pollinators in Nepalese farmers were inadequate and more than 90% of the citrus farmers had no idea of pollinator and pollination of citrus. Information on local people's indigenous knowledge on pollinators and pollination of Shea tree (*V. paradoxa*) in Ghana is nonexistent.

The objectives of this study were therefore

1. To assess the bio-data of Shea nut stakeholders in the Northern Region of Ghana.
2. To examine the knowledge of stakeholders of Shea nut/ butter production (collectors, processors and exporters) in pollination, awareness of Shea pollinators their roles and need to conserve them

Materials and methods

The study area

The study was carried in the Northern Region of Ghana. The Northern Region was purposively chosen because more Shea trees occur in the Northern Region (Guinea savannah) than the upper east and upper west (Sudan savannah) (Chimsah, *et al*.,2013) [8] The Northern Region occupies an area of about 70,383 square kilometers and shares boundaries with the upper East and the Upper Western region to the north, the Brong- Ahafo and the Volta Region to the south, and two neighboring countries, the Republic of Togo to the east, and La Cote d'Ivoire to the west (Asiedu-Bekoe, and Acheampong, 2016 and Hamza *et al*., 2015) [6, 16].

The climate of the region is relatively dry, with a single rainy season that begins in May and ends in October. The amount of rainfall recorded annually varies between 750 mm and 1050 mm (ghana.gov.gh/northern, 2014). The dry season starts in November and ends in March/April with maximum temperatures occurring towards the end of the dry season (March-April) and minimum temperatures in December and January. The dry season (harmattan winds) which occur during the months of December to early February, have considerable effect on the temperatures in the region, which may vary between 14 °C at night and 40°C during the day. Humidity, however, which is very low, mitigates the effect of the daytime heat. The main vegetation is classified as vast areas of grassland, interspersed with the guinea savannah woodland, characterized by drought-resistant trees such as the Acacia, Baobab, Shea nut, Dawadawa, Mango, and Neem (Maanikuu, and P. M. I., 2018 ; Issaka,2018) [23, 19]

Design and Sample population of the study

The study was a descriptive one (Place *et al.*, 2016) [26] which is essentially a survey of the awareness of the importance of Shea pollinators and the need to conserve them among collectors, processors of shea nuts and exporters of Shea butter. The population for the study consisted of all shea collectors, processors and exporters in the Northern region of Ghana. The sample population was the Shea collectors, processors from the 10 districts/municipalities/metropolis of the Northern region (Table 1) and exporters sampled from Tamale.

Sampling procedure

Ten districts and two communities from each of the districts were randomly selected from the 26 districts of the Northern region (Table 1) for survey. Thirty collectors and thirty processors were randomly selected from each community, making 60 collectors and 60 processors per district. Ten exporters were also sampled from the exporters in Tamale. Three separate structured questionnaires were used to collect data.

Table 1: The communities where collectors, processor and exporters were sampled

Districts	Communities
West Mamprusi	Walewale, Sayoo
East Gonja	Salaga, Kpembe
South Nanumba	Wulensi, Kotoya
Tolon-Kunbungu	Tunayili, Gundaa
Savelugu/Nanton	Savelugu, Kanshegu
Yendi	Yendi, Kuga
West Gonja	Damongo, Nabori
Central Gonja	Buipe, Old Bimpe
STamale	Tampiakukuo, Tuuntingli
Karaga	Duyini, Kasheli

Validity and Reliability

In order to achieve validity, the questionnaires were scrutinized and pre-tested. The reliability coefficients of the questionnaires by test retest method were as follows: collectors (+0.88), processors (+0.82) and exporters (+0.79).

Procedure for administration of questionnaires

District coordinators of National Commission for Civic Education (NCCE) of the sampled districts were used for this exercise. This is because they understood the local dialect and interacted with the local people intimately. The coordinators were invited to the regional office for a two-day orientation and training on how to administer the questionnaires. They were taken through the Principal investigator's (PI) letter to the respondents (Appendix S). The importance of this letter was stressed. Each coordinator was given 60 questionnaires for collectors and processors to administer within a month. The questionnaires for the exporters were administered by the researcher and a research assistant who also understood the local dialect, Dagbanli.Respondents were taken through the PIs letter (Appendix S) before the administration of the questionnaire in each case.

Analysis of Data

Responses from respondents were coded and computed in percentages using SPSS version 16.0. Analysis of variance (ANOVA) was used to compare the mean responses on biodata and knowledge in pollination and awareness of Shea pollinators and the need for their conservation among collectors, processors and exporters.

Results

General information on respondents

Collectors and processors were predominantly female whilst exporters were mostly males in (Table 2). There were high significant differences (P<0.0001) in the sex among the stakeholders with collectors recording the highest (97.7%) number of females. Most of the respondents were married (Table 2) there were high significance differences (*P*<0.001) in the marital status among the stakeholders with collectors recording the highest. Most collectors were below 30 years whilst most of the processors (34.8%) and exporters (70%) were above 30years. Majority (83.8%) of collectors and processors (80.6%) and 40% of exporters had no formal education (Table 2). There were high significant differences (*P*<0.001) in the literacy level among the three stakeholders with collectors recording the highest level of illiterates.

Most of the respondents (collectors = 67.4, processors = 66.2, exporters= 47.4) had a household size of between 6 to10 people. Significant differences (*P*<0.01) existed in the household sizes of Shea stakeholders with collectors having the highest (67.4%) family size. On the whole all the respondents were employed which suggested they all have alternative employment apart from Shea. Most of the stakeholders have been doing Shea business for over thirty (30) years (Table 2).

Table 2: General information on respondents

Variable	Response	Response in percentage			F-Value	P-value
		Collectors (n=600)	Processors (n=600)	Exporters. (n=10)		
Sex	Female	97.7	94.3	51.2	315.88	< 0.001
Marital Status	Married	84.2	84.0	57.6	34.94	< 0.001
Age (years)	18-29	33.7	29.3	20.0	Na	na
	30-42	33.5	34.8	70.0		
Educational level	No formal Education	83.8	80.6	51.2	37.74	< 0.001
Employment status	Employed	53.5	62.3	70.0	Na	na
Household Size	6 to 10 people	67.39	66.2	47.4	5.90	0.01
Experience (Number of years in Shea business)	10-20 years and above	34.0	45.5	50.0	Na	Na

Knowledge in pollination

Majority of collectors (79.3%) and processors (65.2%) and half of the exporters (50.0%) had very little knowledge of the general scientific concept of pollination. Only 28.7% of collectors and 34.8% of processor and 50.0% of exporters had knowledge of pollination. There was significant (*P*< 0.001) difference in the responses in the knowledge in pollination (Table 3) with exporters recording the highest. Most of respondents knew that the fruit develop from the flower; only few responded no idea. There was significant (*P*< 0.001) difference in the knowledge of where the fruit is developed from with collectors (87.7%) recording the highest.

However, most of the respondents (collectors -90%; processors -78%; exporters -80%) did not know the effect of destroying plants on insects. There was significant (*P*< 0.001) differences in the responses on the effect of destruction of trees on insects with collectors (76.5%) recording the highest. Most of the respondents (90.2% of collectors, 88.8% of processors and 82.9% of exporters) indicated that not all the insect are useful to the Shea flowers. There were significant (P <0.001) difference in the responses with collectors (90.0%) recording the highest. Majority of the respondents (66.0% of the collectors, 72.5 % of processors and 56.0% of exporters) indicated that the Shea tree will set fruit in the absence of insect. Many respondents (71.3% of collectors, 55.7% of processors and 36.4% of exporters) indicated that bees are the most predominant animals seen on the Shea trees.

About sixty-seven percent (66.7%) of collectors, 63.1% of processors and 36.4% of exporters indicated that unpollinated flowers drop. There was significant (P < 0.001) difference in the responses with collectors 67.7% recording the highest. About 2/3 of the respondents did not know what happened to the fruiting of Shea trees if pollinators were destroyed. Only 24.1% of collectors, 31.3% of processors and 23.1% of exporters know that destruction of pollinators will lead to less fruit production. There was a significant (*P*= 0.04) difference in the response of what happened to fruiting of Shea trees if pollinators are destroyed with processors (31.3%) recording the highest.

Majority of the respondents did not know that pollination were responsible for the different sizes of Shea fruit. Only few of the collectors (11.7%), processors (7.1%) and exporters (23.0%) knew pollinators were responsible for the different sizes of Shea fruits. About half of the respondents indicated that it was not important to encourage Shea flower visitation by insects. There were a significant relationship

between the education level and knowledge in pollination (X^2=38.81; d.f. =6; *P*=0.00)

On personal ways of protecting insect pollinators, responses from the respondents could be ranked as follows; education > passage of bye-laws >stop bush burning > plant more Shea trees.For government and community help to protect insect pollinators, the responses of all stakeholders could be ranked as follows; passage of bye-laws and education on afforestation > awarding of non-bush burners > education on importance of insects to Shea trees (Table 3).

Table 3: Knowledge in Pollination and awareness of pollinators and the need for their conservation

Variable	Response	Response in percentage				
		Collectors (n=600)	Processors (n=600)	Exporters. (n=10)	F – value	p-value
Knowledge in pollination	Yes	28.7	34.8	50.0	46.59	< 0.001
Part of shea tree the fruit develop from	Flower	87.9	78.4	78.2	12.28	< 0.001
	No idea	12.1	21.6	21.8		
Effect of destroying plants on insects	Reduction in insect population	10.0	22.0	20.0	44.45	< 0.001
	Nothing	13.5	35.0	34.5		
	No idea	76.5	43.0	45.5		
Do you think all insects are useful to the flowers?	No	90.8	88.8	82.9	1546.20	< 0.001
	Yes	9.2	11.2	17.1		
Animals seen on Shea flowers	Birds	12.4	8.4	13.0	Na	Na
	Bats	12.5	16.3	19.0		
	Bees	71.3	55.7	36.4		
	Beetles & Ants	3.8	19.6	31.6		
Will the trees set fruits without the insects	No	34.0	27.5	44.0	Na	Na
	Yes	66.0	72.5	56.0		
What happens to the flowers without insects visiting them						
	They drop	67.7	63.1	54.0	289.81	< 0.001
	Nothing	11.0	13.8	15.0		
	No idea	21.3	23.1	31.0		
Effect of destruction of pollinators to the fruiting of Shea trees	Less fruit production	24.1	31.3	23.1	3.87	0.04
	No idea	48.9	56.6	66.9		
	Nothing	27.0	12.1	10.0		

Table 4: Continued: Knowledge in Pollination and awareness of pollinators and the need for their conservation

Variable	Response	Response in percentage				
		Collectors (n=600)	Processors (n=600)	Exporters. (n=10)	F- value	p-value
What do you think is responsible for the differentSizes of Shea fruits?	Pollinators	11.7	7.1	23.0	32.88	< 0.001
	No idea	51.0	45.0	37.0		
	Location of Shea tree	13.0	20.0	21.8		
	Rainfall	15.3	18.0	10.0		
	Shea tree variety	10.0	9.9	8.2		
Do you think it is important to encourage shea flower visitation by insects?	Yes	46.3	51.9	48.1	2.11	0.15
	No	42.6	38.1	40.7		
	No idea	11.1	10.0	11.2		
Personal ways to protect Insects pollinators	Education	45.0	53.0	47.0	Na	na
	Passage of bye laws	33.0	37.0	21.5		
	Plant more Shea trees	7.9	4.0	13.3		
	Stop bush burning	14.1	6.0	18.1		
Government and Community help to protect insects pollinators	Education on importance of insects to shea tree	24.0	34.0	10.4	Na	na
	Awarding non bush burners	32.7	15.0	18.3		
	Passage of bye laws, education on afforestation	43.3	51.0	71.3		

Discussion

From the survey, it is evident the Shea stakeholders (collectors, processors and exporters) have very little understanding of pollination and knowledge of Shea pollination. Their understanding that Shea tree set fruits without the visitation of insects suggests that Shea stakeholders believe Shea flowers do not need pollination. The indifferent responses on what is responsible for the different sizes of Shea fruits affirm their lack of knowledge on pollination. This is in line with a report by Munyuli (2011) that about 90% of coffee farmers interviewed in a study in Uganda were not aware of the role played by bees in coffee

yield increase.

It is also consistent with African Pollinator Initiative (API) (Kleijn, *et al.*, 2015) [20] that there is insufficient knowledge among farmers on the importance of pollination. It appears that Shea collectors, processors and exporters with low education have very low knowledge of pollination. Collectors, processors and exporters usually acquired farm knowledge through personal observation and from experiences passed on by other stakeholders (Venturini, *et al*., 2016) [32].

The nature of foraging behaviour of honey bees, the buzzing sound associated with foraging of Shea flowers and the fact that honey bees might sting when disturbed, so they need to be taken note of might be, the reason why most stakeholders (collectors, processors and exporters) mentioned bees as the major visitors of Shea flowers. Stakeholders such as collectors may have observed bees and the buzzing sound associated with their foraging when they visited the Shea parkland during the blooming season. Honey bee and stingless bee often forage together as both are attracted by the nectar and sweet scent of the Shea flowers. However a local farmer and collectors of Shea nuts cannot easily distinguish the honey bee from the stingless bee such as *Meliponula* sp. high up the Shea tree if he/she is not trained. This might have accounted for most stakeholders mentioning bees as the major Shea flower visitor. They see the guild of bees foraging the shea flowers as *A. mellifera* (honey bees).

On the various methods given on personal, community and governmental ways of protecting and conserving insect pollinators, the responses; education, passage of by- laws, stop bush burning and awarding of non-bush burners suggest that the Shea stakeholders might have benefitted from conservation training and are trying to extend the knowledge to the protection and conservation of insect pollinators. This is because native bee conservation goes hand in hand with conservation of native plants that depend on them for pollination (Delaplane, 2013) but there is a gap, perception is different from implementation. This then calls for a detail training of stakeholders in protection and conservation of insect pollinators of Shea trees in Northern region.

Conclusions

It can be concluded from this study that the Shea stakeholder (collectors, processors and exporters) have very little understanding of pollination and knowledge of Shea pollination. Education on the importance of Shea pollinators, their protection and conservation and activities which favour their abundance on Shea trees is recommended to Shea production stakeholders.

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