

Research Application Summary

Socio-economic impact of *Anacridium melanorhodon melanorhodon* outbreaks on local gum arabic producers in North Kordofan, Sudan

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Abstract

The study was conducted in North Kordofan, Sudan during 2012/2013 season. The study aimed at assessing the socio-economic impacts of the tree locust, *Anacridium melanorhodon melanorhodon* on gum arabic producers. A key informant questionnaire was designed to interview gum Arabic producers in three villages in addition to focus group discussions in each village. A total of 100 producers were interviewed. SPSS was used for data analysis. Results revealed that Gum revenue is used to buy drinking water for 65 % of the producers. Of those interviewed, 98 % of the producers classified the tree locust as the most important pest, where 96 % do not tap their gardens during outbreaks. Further, 55% of the producers estimated the loss between 50% to 75%, causing 66% drop in their revenue. The study concluded that income from gum production is a key pillar for household economy, and Tree locust infestations has negative socio-economic consequences and significantly influences livelihood.

Keywords: *Acacia senegal*, *Anacridium melanorhodon*, Gum losses, Sudan Tree Locust

Résumé

L'étude a été menée dans le nord du Kordofan, au Soudan, pendant la saison 2012/2013. L'étude visait à évaluer les impacts socio-économiques du criquet pèlerin, *Anacridium melanorhodon melanorhodon* sur les producteurs de gomme arabique. Un questionnaire destiné aux informateurs clés a été conçu pour interroger les producteurs de gomme arabique dans trois villages en plus des discussions de groupe dans chaque village. Au total, 100 producteurs ont été interrogés. SPSS a été utilisé pour l'analyse des données. Les résultats ont révélé que les revenus de la gomme sont utilisés pour acheter de l'eau potable pour 65% des producteurs. Parmi les personnes interrogées, 98% des producteurs ont classé le criquet pèlerin comme le ravageur le plus important, 96% ne tapotent pas leurs jardins pendant les flambées. De plus, 55% des producteurs ont estimé la perte entre 50% et 75%, entraînant une baisse de 66% de leurs revenus. L'étude a conclu que le revenu de la production de gomme est un pilier clé de l'économie des ménages, et les infestations de criquets pèlerins ont des conséquences socio-économiques négatives et influencent considérablement les moyens de subsistance.

Mots-clés: *Acacia senegal*, *Anacridium melanorhodon*, Pertes de gomme, Criquet pèlerin du Soudan

Introduction

Gum Arabic is a non-timber forest product from *Acacia senegal* tree. This product is mostly produced by the small-scale farmers in traditional rain-fed farming areas in Sudan. They represent up to 20 percent of Sudan's population and are among the poorest. Small-scale farmers give priority to food crop production (usually sorghum or millet) to secure family nutritional needs but also seek other sources of income to meet the household's basic needs other than grains. In addition to the direct financial returns, they cultivate Gum Arabic because this activity constitutes a crop diversification strategy to mitigate against crop failure. This has substantial beneficial environmental impact, and is an important source of on-farm supply of fuel wood and livestock fodder (Thomas, 2007).

According to FAO (1999), Sudan accounts for 80% of the world's Gum Arabic production and this is the World main source of Gum Arabic (gum Hashab). Kordofan Region in Sudan alone is responsible for 70 % of the national production of Gum Arabic (Jamal and Albany, 1994). *Acacia senegal* tree and Gum Arabic production is regarded as an important ecological component in the savannah belt of the Sudan. In addition to gum production, *Acacia senegal* tree improves soil through biological nitrogen fixation, as well as being a source of firewood, and as fodder (Badi *et al.*, 1989; Elfeel, 1996). Moreover, the Gum Arabic belt acts as a natural barrier against the desert encroachment (Ballal, 2003). Gum Arabic production activities contribute substantially to the income of local farmers in the area and it is considered as a pillar of family economy and as an income-generating source that requires only a low input of work after the rainy season (Mahmoud, 2004). Moreover, Gum Arabic plays an important role in rural life by providing a steady income to rural families especially in dry years when crops fail (FAO, 1999). Nevertheless, livelihoods of a large number of rural Sudanese depend on gum Arabic as an agricultural export commodity produced in central Sudan, but the contribution of Hashab tree in the livelihoods of rural people, the socio-economic aspects related to gum Arabic production and the impact of season failure due to locust outbreak or other factors are not well documented (Koli *et al.*, 2013). Hence the rationale for the study.

Gum Arabic production is seriously constrained by the tree locust *Anacridium melanorhodon melanorhodon* also called the "night wanderer" as the locust swarms fly by night- in addition to some other biotic and abiotic factors. This locust has been reported by FAO (1993) as a regular inhabitant of the Sahelian zone and is considered as important pest of *Acacia senegal*. Tigani (1965) and Popov and Ratcliffe (1968) reported that Sudan is considered as a main distribution area of *A. m. melanorhodon*, with an observed overlap with the other subspecies *A. m. arabafrum* (Dirsh) in eastern Sudan and western Eritrea (Anonymous, 1976). The tree locust spreads on a broad scope, conspicuously in the South-West of Darfur and Kordofan States where it is considered as a serious pest (Johnston, 1932). The pest seriously affects Gum Arabic production where it is reported by the Anti Locust Research Centre (1966), as the most destructive pest to *Acacia senegal* tree. The area infested by *A. m. melanorhodon* in 1987 was estimated at 20, 000 ha, jumping to 224, 000 ha the following season and reaching an unprecedented level in 1989 to cover 1,366,762 ha (Abdalla, 1990). It was the most serious outbreak of tree locust, and the Gum Arabic belt in Western, Central

and Eastern regions of the Sudan, was infested. Damage was reported mainly on *Acacia senegal*. Elamin *et al.* (2008) concluded that the Gum Arabic tree (hashab tree), suffers when attacked by the tree locust *A. m. melanorhodon* during years of outbreak, and the loss of Gum Arabic due to the tree locust -beside ecological aspects- has socio-economic consequences. The defoliation caused by this pest reduces the gum yield and hence grossly affects the livelihood of local farmers. Therefore, there is a necessity to investigate the consequences of the damage caused by such pest as a prerequisite for development of managerial intervention so as to reduce the socio-economic on local gum producers and trade.

Based on the foregoing, the current study was designed to evaluate the socio-economic impact of the tree locust on the local gum producers.

Research Approach

This study was conducted within the Gum Arabic belt of North Kordofan State. The state was divided into three zones according to the production of Gum Arabic (High, Medium and Low) and the following criteria were considered for the selection of specific study sites; the contribution of Gum Arabic production on the farmer's income, the Production classification of the area (High, Medium and Low), and accessibility to the area. Accordingly, three villages were selected; Elsaata village: Abu Zabad locality which was classified as high productivity area, Umhabila village: Rrahad locality, classified as medium productivity area, and ElHimeira village: Sheikan locality which was classified as low productivity area.

A Key informants questionnaire was designed to interview Gum Arabic producers about the socio-economic impacts of the tree locust outbreak. A random sample was chosen for each village according to the total number of the producers. Additionally, a participatory rural appraisal group discussion was conducted in each village. The number of participants for the group discussions varied from six to ten based on the recommendations of Krueger and Casey (2000). In each group, the discussion included the points that appeared to show a difference or to be controversial among the answers of the questionnaire and the discussion continued until the group reached a common view point. Further, there was cross checking between the group discussion and the questionnaire. Data collected from the questionnaire was cross checked with the group discussion, and then subjected to SPSS Statistical package for analysis. Non-parametric measurement and descriptive statistics analysis were done.

Results

The average production of Gum Arabic in the study area during the good season was 558.87, 537.12 and 347.65 kg/ha for Elsaata, Umhabila and Elhimeira villages, respectively, in comparison to 288, 271.6 and 176.6 kg/ha during the normal season for the three villages, respectively (Table 1). As shown in Table 2, the mean price of gum Arabic (at farm gate) recorded an increase where it varied from 0.41 to 0.55 \$ in 2009 to 0.54 to 1 \$ in 2010, and jumping to 1.4 to 1.8 \$ in 2011.

Beside gum production, gum producers in the study area found extra use for Hashab trees, where 58% of them used Hashab trees as building material, firewood, for soil fertility enhancement and as fodder. Nearly, 30% of the respondents emphasized on the use of gum trees for firewood and fruits as well as fodder for the animals Table (1).

Table (2) summarises the expenditures of gum revenues in the study area, where about 65 % of the producers sell their gum to buy drinking water and to cover the living expenses, while 14% invest some of the revenues to cover other living expenses; 3.6 % cover cost of their social contributions from gum revenue, whereas 18 % of the producers in the study area use the gum revenues for all the previously mentioned ways of expenditure.

The most important pest in the study area was the tree locust (98 %), as stated by the local producers (Table 3), while 2 % emphasized the effect of Long horn beetles. The number of tree locust per tree during the outbreak varies from less than 100 up to uncountable as shown in Table (4). The effect of tree locust outbreak on the decision of gum producers to tap their gardens is shown in Table (5), where, 96 % of the producers in the study area confirm that either they delayed the tapping date (80 %) or they feel reluctant and decide to not tap (16%).

Table 1. Benefits and uses of hashab tree in the studied villages according to the respondents' view point

Benefits	Village						Total
	Elsaata		Umhabila		Elhimeira		
	Frequency	%	Frequency	%	Frequency	%	
Building material, Fire wood and fodder	2	8	4	18.2	8	88.9	14
Soil fertility	2	8	0	0	1	11.1	3
Fire wood and foder	10	40	9	40.9	0	0	19
All of them	9	36	8	36.4	0	0	17
Nothing	2	8	1	4.5	0	0	3
Total	25	100	22	100	9	100	56

Table 2. The expenditures from gum Arabic revenue in the selected villages according to the respondents' view point

Gum expenditures	Village						Total
	Elsaata		Umhabila		Elhimeira		
	Frequency	%	Frequency	%	Frequency	%	
Drinking water and living expenses	19	76	12	54.6	5	55.6	36
Living expenses and investment	5	20	2	9	1	11.1	8
Social contributions	1	4	0	0	1	11.1	2
All of them	0	0	8	36.4	2	22.2	10
Total	25	100	22	100	9	100	56

Table 3. The most serious pest species that attack Hashab trees according to the respondents view point

Village	Pests				Total
	Tree locust		Long horn beetles		
	Frequency	%	Frequency	%	
Elsaata	24	96	1	4	25
Umhabila	22	100	0	0	22
Elhimeira	9	100	0	0	9
Total	55	98.2	1	1.8	56

Table 4. The number of tree locust per tree in the selected villages according to the respondents' view point

Village	Number of locust per tree						Total
	< 100		100 - 500		Uncountable		
	Frequency	%	Frequency	%	Frequency	%	
Elsaata	1	4	4	16	20	80	25
Umhabila	1	4.5	4	18.2	17	77.3	22
Elhimeira	1	11	4	44.5	4	44.5	9
Total	3	5.4	12	21.5	41	73.1	56

Table 5. Tapping date in case of Tree locust outbreak in the selected villages according to the respondents' view point

Village	Early tapping		Late tapping		No tapping		Total
	Frequency	%	Frequency	%	Frequency	%	
Elsaata	1	4	19	76	5	20	25
Umhabila	1	4.5	18	81.8	3	13.7	22
Elhimeira	0	0	8	88.9	1	11.1	9
Total	2	3.6	45	80.4	9	16	56

As shown in Table (6) 100% of the gum producers in the study area confirmed that the tree locust cause apparent loss in the production. Only 7% of them classified the loss in gum production as less than 50 % and 55% of the producers stated that they lose between 50% to 74% of gum production, while 38% of the respondents classify the loss as between 75% and 100%.

The consequences of the loss in production due to tree locust outbreak or season failure appear in the producers' reaction to compensate (Table 7). As stated by the respondents in the study area, 55 % of them sell animals or stored crops to cover the loss, while those who do not have livestock (11%), they travel to seek for work or undertake gold digging. Day-laboring or logging compensate for about 21%, whereas about 13 % have no means of compensation Table (7).

According to the export price of gum Arabic in 2013, and the mean production in each village, the benefits from gum was calculated in US\$ per hectare. The results showed that in Elsaata village there is highly significant drop in producers benefit in case of locust outbreak, where, in the good season the mean benefit \$/ha reached (1701.74 \$) as compared to 574.55 \$ with locust outbreak (Table 8). Almost the same results were also obtained in Umhabila and Elhimeira villages, where the mean benefit without tree locust outbreak was 1635.42 and 1057.43 \$/ha, respectively. On the other hand, the mean benefit in case of tree locust outbreak was just 549.52 and 363.33 \$/ha for the two villages, respectively (Tables 9 and 10).

The producers benefit from gum production was calculated for three years 2009/10/11 according to the price in which they sold their gum. Generally, the benefit increased year by year according to the increase in price, and decreased in case of locust outbreak. In Elsaata village the mean benefits without outbreak were 264.0, 585.1 and 1046.7 \$/ha for 2009/10/11, respectively, and the mean loss in production with outbreak as 85.70, 196.4 and 355.6 \$/ha for the three years, respectively, as shown in Table 11-13. Further, Tables 11 - 13 also show the minimum, maximum and mean benefit in \$/ha from gum Arabic for local producers in the study areas with and without locust outbreak according to the price at farm gate. Highly significant reduction in the benefits with tree locust outbreak was apparent in comparison to the mean benefits without outbreak.

Table 6. Mean loss (%) in gum production due to Tree locust outbreak in the selected villages according to the respondents' view point

Village	Loss in production (%)						Mean	SD±
	less than 50%		50%-74%		75%-100%			
	Frrequency	%	Frrequency	%	Frrequency	%		
Elsaata	2	8	13	52	10	40	68.4	20.5
Umhabila	2	9	13	59.2	7	31.8	66.6	19.0
Elhimeira	0	0	5	55.6	4	44.4	64.4	18.6
Total	4	7.1	31	55.4	21	37.5	66.5	

Table 7. Means of compensation for local gum Arabic producers in case of season failure in the selected villages according to the respondents' view point

Villages	Elsaata		Umhabila		Elhimeira		Total	%
	Frrequency	%	Frrequency	%	Frrequency	%		
Travel for work or gold digging	3	12	2	9.1	1	11.1	6	10.7
Sale livestock or stored crops	14	56	11	50	6	66.7	31	55.4
Day-laborer or Logging	5	20	6	27.3	1	11.1	12	21.4
Do nothing	3	12	3	13.6	1	11.1	7	12.5
Total	25	100	22	100	9	100	56	100

Table 8. Gum Arabic benefits (\$/ha) for local producers -in export price 2013- with or without tree locust outbreak in Elsaata village

Benefit (\$)	Minimum	Maximum	Mean	SD±
Benefit in good season	529.74	3802.47	1701.74	679.26
Benefit in normal season	253.57	2533.43	875.35	418.15
Benefit during locust outbreak	.00	1826.08	574.55	437.15

Table 9. Gum Arabic benefits (\$/ha) for local producers -in export price 2013- with or without tree locust outbreak in Umhabila village

Benefit (\$)	Minimum	Maximum	Mean	SD±
Benefit in good season	913.13	2433.69	1635.42	366.00
Benefit in normal season	456.30	1139.76	825.56	179.09
Benefit during locust outbreak	.00	1216.85	549.52	338.44

Table 10. Gum Arabic benefits (\$/ha) for local producers -in export price 2013- with or without tree locust outbreak in Elhimeira village

Benefit (\$)	Minimum	Maximum	Mean	SD±
Benefit in good season	606.47	1519.94	1057.43	345.01
Benefit in normal season	301.89	758.54	535.72	165.75
Benefit during locust outbreak	.00	758.63	363.33	248.63

Discussion

The results of the survey gave some estimates for the losses in gum production from Hashab trees due to tree locust infestation according to the producers' point of view. In this context, the majority of the respondents (55%) estimated the loss to range between 50% and 74% from total gum production. The mean loss in the present study (66.5%) was in line with the results obtained by Elamin *et al.* (2008), who estimated the mean loss at 46.5% from the total production. In this study, 80 % of the producers confirmed that they decide to delay tapping in case of locust outbreak. Ballal (2003) pointed out that, the gum yield decreased by about 30% in mid-November tapping, and dropped to about 60% in early December tapping because of the loss of carbohydrate resources essential for gum production.

The loss in gum production reflected negatively on the benefits to the local gum producers (Tables 11-13), as the majority of the respondents in the present study (55%) stated that they use the revenues from gum production to buy drinking water and to cover their living expenses. This loss could be of socio-economic impact especially on the producers who have no means for compensation or

those who react by migration seeking for work (Table 7). These findings are in line with Elamin (2008) who concluded that tree locust outbreak reduced the average benefits per hectare from 292.6 to – 21.2 SDG according to the estimations by gum producers. These results are in line with Taha (2006), who reported that Gum Arabic is a significant source of cash income for the rural household communities in the gum belt, where it accounted for about 15.3% of the household income of Gum Arabic producer and 10% of other farmers' income within the gum belt across the Sudan. However, Koli *et al.* (2013) stated that the contribution of Hashab tree in the livelihoods of rural people, socio-economic aspects pertinent to gum Arabic production and the impact of season failure due to locust infestation during outbreak periods were not yet known. This drive us back again to the fact that there is limited literature available on the subject.

Conclusion

The literature on the socio-economic impact and the control of the Tree locust as pest of *Acacia senegal* is scanty. This study concluded that: income from gum production is a key pillar for household economy, and Tree locust infestations has negative socio-economic consequences and influenced their livelihood of the affected people. Further studies on the environmentally friendly management methods for such pests are needed as a prerequisite for development of managerial concepts of intervention so as to improve the socio-economic situation of local gum producers in Sudan and beyond.

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References

- Abdalla, A. A. 1990. Review of the (1989-1990) Situation of Grasshoppers, Tree Locust and African Migratory Locust in the Sudan. And outlook for (1990 -91). Ministry of Agric. PPD - Khartoum North- Sudan.
- Anonymous, 1976. Common wealth Institute of Entomology. Pest: *Anacridium melanorhodon* (Walker) (Including *A. m. arabafrum*, Dirsh) (Ortho., Acrididae) (Sahelian Tree Locust). Distribution maps for insect pests, (ser. A), No. 355.
- Anti-Locust Research Centre, 1966. Anti- Locust Memoir 9, 48pp. College House, Wrights Lane, London
- Badi, K. H. M., Ahmed, A. E. and Bayoumi, M. S. 1989. The Forest of the Sudan, Khartoum, 184pp.
- Ballal, M. E. 2003. Yield trends of gum arabic from *Acacia senegal* as related to some

Table 11. Gum Arabic benefits (\$/ha) for local producers in farm gate price 2009, 2010 and 2011 with or without tree locust outbreak in Elsaata village

Benefit (\$)	2009				2010				2011			
	Min	Max	Mean	SD±	Min	Max	Mean	SD±	Min	Max	Mean	SD±
Benefit in good season	20.55	944.2	264.0	237.45	30.96	1430.8	585.1	332.5	103.4	2379.5	1046.7	497.1
Benefit in normal season	8.07	627.8	129.12	125.06	12.23	952.3	301.3	197.5	42.2	1584.8	532.2	287.0
Benefit During locust outbreak	0.00	283.21	85.70	83.27	.00	590.9	196.4	168.4	0.00	1065.2	355.6	277.5

Table 12. Gum Arabic benefits (\$/ha) for local producers in farm gate price of 2009, 2010 and 2011 with or without tree locust outbreak in Umhabila village

Benefit (\$)	2009				2010				2011			
	Min	Max	Mean	SD±	Min	Max	Mean	SD±	Min	Max	Mean	SD±
Benefit in good season	74.3	404.6	218.0	95.2	92.3	568.2	294.7	146.4	305.0	1419.1	744.9	228.4
Benefit in normal season	36.9	200.1	107.6	43.6	45.9	250.0	145.2	69.1	152.2	589.7	375.1	107.9
Benefit During locust outbreak	0.00	202.3	75.8	0.00	0.00	240.7	104.3	77.0	0.00	709.6	261.9	191.7

Table 13. Gum Arabic benefits (\$/ha) for local producers in farm gate price of 2009, 2010 and 2011 with or without tree locust outbreak in Elhimeira village

Benefit (\$)	2009				2010				2011			
	Min	Max	Mean	SD±	Min	Max	Mean	SD±	Min	Max	Mean	SD±
Benefit in good season	60.5	628.5	205.8	171.2	99.2	1013.0	333.2	284.1	302.9	1267.6	633.2	344.9
Benefit in normal season	33.3	311.5	102.2	84.4	48.3	503.7	166.6	140.4	150.1	631.0	318.7	168.7
Benefit During locust outbreak	0.00	314.3	74.9	94.0	0.00	506.5	120.1	153.9	0.00	633.8	230.7	212.1

- environmental and managerial factors, Faculty of Forestry, University of Khartoum, Khartoum, Sudan. 105 pp.
- Elamin, H. M. A., Roth, M. and Taha, M. E. 2008. The consequences of defoliation of gum arabic tree (*Acacia senegal*) by Sahelian Tree Locust (*Anacridium melanorhodon melanorhodon*) for the gum producers in North Kordofan State, Sudan. Proceeding of the Conference on International Research on Food Security, Natural Resource Management and Rural Development, Tropentag 2008.
- Elfeel, A. A. 1996. Provenance variation in seed characteristic, germination and early growth trails of *Acacia senegal*. MSc. Thesis, Faculty of Forestry, University of Khartoum, Khartoum, Sudan.
- Food and Agriculture Organisation (FAO). 1993. Guide to Migrant Pest Management in Africa. Food and Agriculture Organization of the United Nations.
- Food and Agriculture Organisation (FAO). 1999. Medicinal, culinary and aromatic plants in the near East. Proceedings of the International Expert Meeting organized by the Forest Products Division FAO Forestry Department and the FAO Regional Office for the Near East 19 - 21 May 1997 Cairo, Egypt.
- Jamal, A. 1994. Major insect pests of gum arabic trees *Acacia senegal* Willd. and *Acacia seyal* L. in Western Sudan. *Journal of Applied Entomology* 117 (1-5): 10-20.
- Johnston, H. B. 1932. Notes on two locusts of minor economic importance in the Sudan. *Bulletin of Entomological Research* 23 (1): 49-64.
- Koli, A.O., Eltayeb, A.M., Sanjak, E.M. and Mohammed, M.H. 2013. Socio-economic aspects of gum arabic production in Dalanj area, South Korodofan, Sudan. *Pakistan Journal of Biological Sciences* 16 (21): 1407-1410.