NASS JOURNAL OF AGRICULTURAL SCIENCES

Volume 4 Issue 1 January 2022 ISSN 2661-3328(Online)

NASS
NAN YANG ACADEMY OF SCIENCES

Volume 4 Issue 1 • January 2022 • ISSN 2661-3328 (Online)

NASS Journal of Agricultural Sciences

NASS
NAN YANG ACADEMY OF SCIENCES

Volume 4 | Issue 1 | January 2022 | Page1-79

NASS Journal of Agricultural Sciences

NASS Journal of Agricultural Sciences
http://ojs.nassg.org/index.php/NJAS

Management Practice and Comparison of Reproductive and Productive Performance of Dairy Cattle between Beneficiary and None Beneficiary of Estrus Synchronization and Mass Insemination in North Shewa Zone, Amhara Region, Ethiopia

Sharew Mekonnen* **Belete kuraz** **Mulugeta Tesfaye**

Department of Animal science, College of Agriculture and natural resource, Werabe University, Ethiopia

ARTICLE INFO

Article history
Received: 21 June 2021
Accepted: 14 December 2021
Published Online: 29 December 2021

Keywords:
Management practice
Beneficiary and none beneficiary
Estrus synchronization
Mass insemination

ABSTRACT

The aim of this study was to assess the overall management practice and comparison of reproductive and productive performance between beneficiaries and none beneficiaries of oestrus synchronization and mass insemination (OSMI) of dairy cattle in north shewa zone of dairy cattle. Data were obtained by interviewing 270 estrus synchronization and mass insemination beneficiaries and 135 none beneficiaries' dairy farmers. Data were analyzed using Statistical Packaging for social science (SPSS) version 20. Natural pasture and crop residue were the most common feed resources in the study areas. River water was the major source of water for their cattle and well water was used when river water is not available. In their order of importance; FMD, mastitis, and abortion were the major diseases of cattle in the study area. The reproductive performance of dairy cows in OSMI beneficiaries were age at first service (30.81±7.6), calving interval (6.9±5.2), lactation length (8.95±2.46), day open (5.3±3.18) and number of service per conception (1.5±0.38) whereas in none beneficiary age at first service (32.88±6.64), calving interval (18.18±5.8), lactation length (9.6±0.54), day open (5.17±3.43) and number of service per conception (1.22±0.54) months. There was a significant ($p<0.05$) difference in milk yield between beneficiaries and none beneficiaries in HFC, HHFC and JERC dairy cows per day per cow.The major factors affecting reproductive performance of dairy cows are management, nutritional status, genotype, and disease. Therefor the productive and reproductive performance of the dairy cows reared by the participants were better than those of the nonparticipants.

1. Background

Oestrus synchronization involves manipulating the oestrus cycle of females, so they can be bred at approximately the same time, thereby saving both time and logistics and this biotechnique also involves regulating the follicular development and thereby provides multiple stimuli thereby inducing oestrus cycle [1]. Synchronization programs are selected from several predesigned protocols which have been scientifically proven to regulate follicular development [2]. Oestrus synchronization (under a smallholder context) can be used as a tool to effectively use natural resources when available abundantly to

**Corresponding Author:*
Sharew Mekonnen,
Department of Animal science, College of Agriculture and natural resource, Werabe University, Ethiopia;
Email: sharewmekonnen@gmail.com

 DOI: http://dx.doi.org/10.36956/njas.v4i1.391

parturates healthy calves and also to evade the period when there is shortage of feed and fodder [3]. Under Ethiopian context parturitions can also be programmed in a way that it coincides with the periods when there is less demand for milk and dairy products [4]. It can also be used as a tool to efficiently use the Artificial insemination [4]. In addition, synchronization of oestrus contributes to optimizing the use of time, labour, and financial resources by shortening the calving season [5]. Thereby increasing the uniformity of the calf crop, exhibit standing oestrus at a predicted time, conceive earlier in the breeding season, and calve earlier in the calving season [6].

Oestrus Estrous synchronization also enables the farmers to reduce costs involved in the hire of AI technicians and semen import in addition to this concentrated calving and uniform weaning saves time and is cheaper than having individual cows in heat throughout the year [6]. This can be achieved through efficient and accurate detection of oestrus, proper semen handling techniques, and thereby timely AI [7]. Failure of proper oestrus detection is the most common problem in dairy cattle breeding programs [8]. Thereby resulting in loss of lifetime milk yield, decrease in number of calves born per lifetime, more numbers of days open, and an increase of reproductive culling were reported by [7]. As the accuracy and efficiency of oestrus detection declines, it is important to incorporate oestrus synchronization/induction and timed AI into the breeding management program. Oestrus synchronization assists in the accomplishment of faster livestock improvement programs such as fixed time artificial insemination (FTAI) and super ovulation of cows, thus minimizing the costs, time and labour required for oestrus detection in cows and does away with buying superior dams and sires. In line with this scenario it was proposed that artificial insemination which follows the oestrus detection can assist in increasing the numbers of crossbreds in Ethiopia [2].

According to [9] management factors such as accuracy of heat detection, timing of insemination, proper insemination techniques, semen quality, proper semen handling and skills in pregnancy diagnosis have been reported to decrease the NSC. [10] added that proper heat detection; feeding and postpartum reproduction management may reduce NSPC. Furthermore [11] revealed that the changes in management system and environmental condition from year to year delays age at first service and calving [12]; [13] indicated that possible causes of low conception rates at first service may fall into different categories: problems related to heat detection: not servicing a cow that is in heat, improper timing of service, misidentification of cows leading to errors in records. The reproductive efficiency of the cow can be attributed if the cow parturates regularly. The world strategy is "One calf per year per cow", in order to achieve this strategy in the country, the calving interval need to be optimized [14]. In this context, oestrus synchronization as reproductive management tool was initiated in 2013 in North Shewa zone of Amhara region [15].

2. Statement of the Problem

Synchronization program was started on a pilot scale by the Bureau of Agriculture in North Shewa zone in 2006/2013. Now a day expand in to Siyadebrnawyu, Tarmaber, Angolelanatera, Debre Birehan town and Basona worena districts. Records till 2017 indicated that in the three districts Siyadebrnawyu, Angolelanatera, and Basona worena districts of North Shewa zone 9097cows were synchronized and 5074 dairy cows inseminated. The present study was initiated due to no any detailed comprehensive study on management practice and comparison of reproductive and productive performance between beneficiary and none beneficiary of estrus synchronization and mass insemination of dairy cattle in North Shewa zone [15], (2013-2017) with the following objectives to assess management practice and compare of reproductive and productive performance of dairy cows between beneficiary and none beneficiary of oestrus synchronization and mass insemination including the major constraints why not farmers participate in OSMI program.

3. Materials and Methods

3.1 Description of the Study Areas

The current study was conducted in DebreBirhan milk shed area of North Shewa zone. North Shewa Zone is bordering on the north by DebubWollo zone, on the east by the Afar Region and from the south and the west by the Oromia region. The zone is located at about 177 km east of the capital Addis Ababa. Its latitude and longitude are 90^{o} 40' 19.3"N and 390^{o} 31' 45.3" E, respectively (Google map satellite). The selected districts are Siyadebrnawyu, Basona worena, and Angolelatera. Siyadebrnawyu. Basona worena is located at the eastern edge of the Ethiopian highlands in the north Shewa Zone. The town of DebreBirhan is an enclave inside this woreda. Angolelanatera is found in west of DebreBirhan town and is located 120 km east of the capital city of Addis Ababa. The average minimum and maximum rain fall is 750 and 1100 mm respectively. Its human and cattle population is 2,080,080 and 1,482,346 heads respectively (Ethiopian

DOI: http://dx.doi.org/10.36956/njas.v4i1.391

CSA, 2016/17) respectively. According to [15], its climatic conditions 32.02% were highland and 45.58% midland. The main feed resource of the area is grazing land, crop aftermath and crop residue. The farming system is largely characterized by mixed farming system.

Map indicating the selected districts

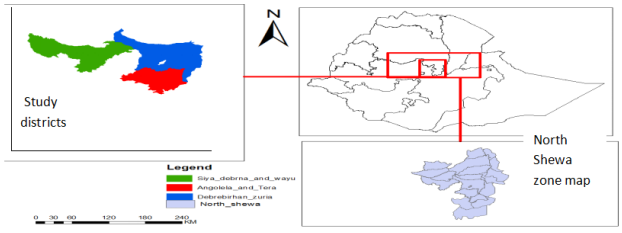


Figure 1. Map of the study areas

3.2 Sampling Procedures

Based on number of synchronized dairy cows, AI practice, number of farmers those adopt oestrus synchronization and mass insemination (OSMI) technology, milking shed potentiality, accessibility, and availability of infrastructure, out of 27 districts three districts (Siyadebrnawyu, Basona worena, and Angolelatera) were selected using multi-stage stratified purposive sampling followed by random sampling technique. To compare productive and reproductive performance of dairy cows, farmers stratified as beneficiaries and none beneficiaries of OSMI, the number of farmers that involved in the OSMI was identified from Kebele, districts and zone record data and from these farmers 270 beneficiaries and 135 farmers not involved in the OSMI were selected randomly per districts. And sampling animals based on breed were classified in to Native, HFC and JERC. Based on the Yemane (1967) sample formula with 95% confidence level, totally 405 households head were selected for the study to represent the zone.

$$\mathbf{n} = \frac{\mathbf{N}}{\mathbf{1} + (\mathbf{N} * \mathbf{e}^{\mathbf{2}})}$$

Where n=sample size, N=number of population in the three districts, e=0.05 margin error.

3.3 Data Collection Method

Data were collected from primary and secondary sources. Primary data was collected using structured questionnaire. For this a structured questionnaire was prepared and pre-tested for its applicability before its administration to the potential respondents and every respondent included in the study was briefed about the objective of the study before starting and presenting the actual questions. Interview was done by the enumerators together with researcher. Separate questionnaires were also prepared for the artificial insemination technicians, livestock experts in the districts and zone. To identify the difference between beneficiaries and none beneficiaries in productive and reproductive performance of dairy cows data were collected through interview from 270 beneficiaries and135 none beneficiaries of farmers.The management practice and factors information collected from 405 respondents.

A focus group discussion was held with those who were associated with estrus synchronization and none-associated farmers. Focus group discussion was also organized in each selected kebeles included 5-12 members at most focused on the history of the management practice of dairy cows and AI services, major constraints why not farmers participate in OSMI program and opportunities of the oestrus synchronization and mass insemination (OSMI).

Secondary data were also collected from zonal, districts and kebeles agricultural administrates documents.

3.4 Data were Collected

The data that were collected through the survey include productive and reproductive performance of dairy cows, livestock feed types, factor affecting conception rate, constraint and opportunities of AI and mass oestrus synchronization, perception of the farmer on mass estrus synchronization including management practice of diary cows.

3.5 Data Analysis

After all the data were collected fed to Ms-Excel (2010) and analyzed by SPSS version 20 Quantitative data obtained from the survey were analyzed by using one way ANOVA. Whereas qualitative data analyzed by chi-square using cross tabulation.

The reproductive performance of the dairy cows as computed the following formula:

$$\text{NSPC} = \frac{\text{numberofconceived cows/heifers}}{\text{number ofinseminated cows/heifers}}$$

The Model used for reproductive and productive perfor-mance of dairy cows.

$$\mathbf{Yij=\mu+ai+bj+Ck+eij}$$

Where yij=response variable (AFS, LL, DO, CI, NSPC)

μ =Overall mean

ai=fixed effect of i^{th} districts (i=3: Angolelanatera,

Basonaworena and Siyadebrnawyu)

bi= fixed effect of j^{th} breeds (j=3: Native, HFC, HHFC)

Ck=fixed effect of k^{th} OSMI (K=2: beneficiary and none beneficiary of OSMI)

eij= residual error

4. Results

4.1 Educational Status and Ratio of Land Holding to Family Size

The results pertaining to the educational status and ratio of land holding to family size of the respondents are presented in Table 1. Furthermore the major respondents in across the study areas Basona worena, Siyadebrnawyu and Angolelanatera were attained grade 1-8, and followed by read and write however this included respondents from illiterate to those who were well educated (>12 class). The studies further indicate that the total land holding to family size was not significance difference between the districts.

Table 1. Educational status and ratio of land holding to family size of the respondents in the study areas

	Districts			
	Basona worena (N=135)	Siyadebr-nawyu (N=135)	Angolelanatera (N=135)	Overall (N=405)
Educational status (%)				
Illiterate	10.4	13.3	11.1	11.6
Read and write	40.7	30.4	37.0	36.0
1-8	38.5	37	55.5	51.8
9-12	8.9	13.4	13.3	11.9
>12	1.5	5.9	6.7	4.7
The ratio of land holding to family size in (mean)				
	0.638/1.92	0.520/1.88	0.535/1.89	0.56/1.94

4.2. Total Cattle Herd Size Per Household

The findings as presented in Table 2 show that there were no differences in the her composition of the native cattle across the studied locations, except that of the numbers of oxen numbers of which were higher in Angolelanatera when compared to the other two locations. The overall results also show that the numbers of native cattle were higher (P<0.05) at Angolelanatera.

The results further indicate that the numbers of Holstein Friesian crosses (F_1 and 62.5% Holstein Friesian) (HFC) were too varied (P<0.05). The findings pertaining to the higher Holstein Friesian crosses (≥ 75% Holstein Friesian blood levels) too varied across the studied locations with higher numbers of cattle being reared at Angolelanatera and Basonworena. The results pertaining to the numbers of Jersey crosses indicated that the numbers did not vary across the studied locations.

Table 2. Total cattle herd size per household by District and breed type in study areas of North shewa (Mean±SD)

Types of cattle category	Districts			
	Basona worena (n=135)	Siyadebrnawyu (n=135)	Angolelanatera n=(135)	Overall N=405
Native	3.0±2.1[a]	3.5±1.9[ab]	3.83±2.1[b]	3.43±2.01
HFC	6.86±3.8[b]	4.23±2.5[a]	6.5±2.96[b]	5.87±3.35
HHFC	1.91±.9[ab]	1.00±.00[a]	2.47±1.2[b]	2.09±1.2
JERC	4.25±1.36	3.00	---	2.42±0.5

a-b means with the different superscripts under the same row for the same parameter is significantly different at p<0.05, SD-standard deviation, = Jersey cross, HFC=Holstein Frisian cross, HHFC, higher Holstein Frisian cross (>75% blood level).

4.3 Management Practice of Dairy Cows

4.3.1 Feed Resources and Feeding System

The results as presented in the study areas pertaining to the availability of feed and fodder across the studied locations are presented in Table 3. The findings show that fodder was available the year round in most of the locations, with variations (P<0.05) across the studied locations. The results were indicative that the availability was lower at A with no differences across both the other locations. The study further indicates that conservation and storage of fodder is practiced across all the locations.

The study also shows that at S District the respondents cultivated fodder oats while in the other two locations the respondents provided fodder which was a mixture of vetch(Vicia sativa) and oats(Avena sativa) fodder.

Table 3. Annual feed availability and cop up mechanism during dry and wet seasons in North Shewa zone (%)

Feed availability/ year	Basonaworena N=135	Siyadebrnawyu N=135	Angolelanatera N=135	Overall N=405
Available	76.4	79.3	51.8	69.17
Not available	23.6	20.7	48.2	30.83
Cope up mechanisms				
Storing the fodder	84.4	80.8	78.5	81.2
Purchasing the fodder	3.1	3.8	15.4	7.43
Feeding the animals every alternate feeds	---	11.6	1.5	4.4

DOI: http://dx.doi.org/10.36956/njas.v4i1.391

Feed availability/ year	Basonaworena N=135	Siyadebrnawyu N=135	Angolelanatera N=135	Overall N=405
Purchasing &storing the fodder	12.5	3.8	4.6	6.97
Type cultivate forage				
Oat	18.0	61.5	34.6	38.03
Vetch	6.0	38.5	11.6	18.77
Mixed	76.0	0	53.8	43.2

4.3.2 Source of Water during Dry and Wet Seasons

The study pertaining to the source of water across the seasons (Table 4) indicate that river water predominated at Basona worena District while in Siyadebrnawyu District the water was mostly provided from wells and rivers during the dry season , while in the wet season the water was mostly obtained from the ponds. The study further indicates that river as source of water predominated in the dry season at Angolelanatera District while river, pond and tap water were the sources during the wet season.

4.3.3 Housing System of Cattle Prevailing in the Studied Districts

The results pertaining to the housing of the cattle reared in the studied locations are presented in Table 5. The findings show that most of the respondents house their cattle in houses which are prepared from stone (wall and floor) with thatched roof. These observations were consistent across the studied Districts. The findings also show that the drainage system was satisfactory only at Angolelanatera District while the reverse was observed in the other two locations. The findings also showed that there was no separate houses for the cattle in Basonaworena and Angolelanatera Districts while most of the cattle raised at Siyadebrnawyu District were provided with separate houses. The study further indicates that the cattle were not provided with separate managers in most of the Districts.

Table 4. Water source during dry and wet season in North Shewa zone (%)

Water source	Districts						
	Basonaworena (n=135)		Siyadebrnawyu (n=135)		Angolelanatera (n=135)		
	Dry (%)	Wet (%)	Dry (%)	Wet (%)	Dry (%)	Wet (%)	Overall
River	61.4	56.4	38.5	9	68.9	34.1	44.7
Pond	29.7	42.9	5.9	75.5	---	34.8	31. 5
Tape	7.4	0.7	21.5	14.8	31.1	31.1	17.8
Well	1.5	---	34.1	0.7	---	---	6
Separate waterier ***	***			***			
Users		12.6		0.7		----	4.4
None users		87.4		99.3		100.0	95.6

* means with significantly different under the same row for the same parameter is at *** p=0.001

Table 5. The percentage of housing system of dairy cattle in the study area of North Shewa N=135

Type of housing (%)	Districts			
	Basonaworena	Siyadebrnawyu	Angolelanatera	Overall
Wood wall stone floor thatched roof	17.0	38.5	14.1	23.2
Stone wall stone floor thatched roof	73.5	48.3	71.9	64.53
Mud walls with tin roof	4.4	4.4	0.7	3.17
Cement floors with tin roof	5.1	8.8	13.3	9.1
Drainage & Ventilation (%)				
Only ventilated	3.0	6.7	7.4	5.7
Only drained	11.1	23.0	9.6	14.53
Well drained and ventilated	29.6	27.3	68.9	41.97
Poorly drained and ventilated	56.3	43.0	14.1	37.8
Presence of separate house for dairy cows (%)				
Absent	85.9	32.6	98.5	72.3
Present	14.1	67.4	1.5	27.7
Presence of separate manger (%)	***	***	***	
Present	19.3	0.7	26.7	15.57
Absent	80.7	99.3	73.3	84.43

** Means with the different superscripts under the same row for the same parameter between season is significantly different at p=0.001, N=number of respondents per districts.

 DOI: http://dx.doi.org/10.36956/njas.v4i1.391

4.3.4 Common Dairy Cow Disease

The findings pertaining to the diseases in cattle in the studied Districts show that foot and mouth disease (FMD) followed by mastitis the diseases were observed across all the locations. The other problem that was commonly observed was abortion among the cattle; however the exact nature of the abortion was not ascertained.

4.3.5 Reasons of Culling of Cattle Reared in the Studied Locations

The reasons pertaining to the culling of cattle in the studied locations are presented in Table 7. The study shows that at B most of the time the cattle are sold off to meet immediate cash needs while in S an A Districts the cattle are culled for meat production. The study further showed that most of the respondents had to travel anything between 1-5 km to visit the veterinary clinics, however some of them have reported that the clinic may be within the kebele itself, the respondents also indicate that most of them depended on the government clinics to get their cattle treated.

4.4 Productive and Reproductive Performance of Dairy Cows between Beneficiary and None Beneficiary of OSMI

4.4.1 Reproductive Performance of Dairy Cows between Beneficiary and None Beneficiary of OSMI

The mean value of AFS, CI, LL, DO and NSPC in OSMI beneficiaries were 40.5±13.6, 17.6±6.4, 8.52±2.4, 5.5±3.75 and 1.49±0.6 respectively whereas 42.7±9.12, 19.46±4.5, 9.15±3.55, 6.2±3.1 and 1.30±.49 in none OSMI beneficiaries with the respective of AFC, CI, LL, Do and NSPC (Table 5). OSMI beneficiaries had been better reproductive performance in HFC and JERC dairy cows as compared to none OSMI beneficiaries.

The age at first service of the native cattle as presented in Table 8 show that varied ($P<0.05$) across the studied breed with higher values reported among the cattle raised HFC and JERC. The AFS of the HFC crosses indicated that the values were higher ($P<0.05$) among the JERC. There were differences among the breed in CI, LL, DO, NSPC as presented in Table 8. Reproductive performance of dairy cattle across the three breed was significantly deference in all parameter in the same row.

4.4.2 Milk Yield between Beneficiary and None Beneficiary of OSMI

Milk yield between beneficiary and none beneficiary of OSMI was presented in Table 9. The finding shows that there is no significant difference ($p>0.05$) between beneficiary and none beneficiary in milk yield of native dairy cows. The overall average milk yield of native dairy cows was 1.63 L per cow per day /L in beneficiary on the other hand 1.5 L per day obtained none beneficiary from native dairy cows. The current result pertaining that there is slight significance ($p<0.05$) difference between beneficiary and none beneficiary in HFC, HHFC and JERC dairy cows per day per cows in milk yield. An overall average milk yield of 6.2 L and 3.3 L per day obtained by beneficiary farmers from HFC and JERC dairy cows respectively while 5.2 L and 2.3 L were obtained by none beneficiary from HFC and JERC dairy cows respectively (Table 6).

Table 6. Cause of cattle culling and Distance of clinic with source of medicine in the study areas (n=135)

Reason of culling cattle	Districts			Overall
	Basonaworena (%)	Siyadebrnawyu (%)	Angolelanatera (%)	
Financial requirement	55.1	20.7	23.5	33.1
Poor production potentials	25.1	1.7	---	8.9
For meat production	11.2	70.7	56.3	46.1
Poor body conformation	8.6	6.9	20.2	11.9
Distance of clinic				
Less than1km	34.8	30.4	12.6	25.9
1-5km	53.3	65.2	86.7	68.4
6-10km	11.1	4.4	0.7	5.43
> than10km	0.8	---	---	0.27
Source of medicine				
Veterinary	85.2	80.78	100.0	88.7
Private pharmacy	9.6	19.22	0	9.61
Market	5.1	0	0	1.73

DOI: http://dx.doi.org/10.36956/njas.v4i1.391

Table 7. The mean plus standard deviation of the reproductive performance of dairy cows between beneficiaries of OSMI and none beneficiaries of OSMI in the study districts in month

	Breed	Native	HFC	JERC	Overall
AFS	Beneficiary	40.5±8.6	31.78±8.3	20.14±5.9	30.8±7.6
	None beneficiary	42.7±9.12	34.88±7.2	21.07±3. 6	32.88±6.64
CI	Beneficiary	17.6±6.4[a]	17.1±4.31[a]	16.0±4.8[a]	16.9±5.2
	None beneficiary	19.5±4.5[b]	17.1±4.6[a]	18.0±8.5[b]	18.18±5.8
LL	Beneficiary	8.52±2.4[a]	9.4±1.95[a]	8.9±3.10[a]	8.95±2.46
	None beneficiary	9.15±3.55[a]	9.16±1.8[a]	10.5±4.9[b]	9.6±0.54
DO	Beneficiary	5.5±3.75[a]	5.12±2.9[a]	5.21±2.9[b]	5.3±3.18
	None beneficiary	6.2±3.1[a]	5.30±2.6[a]	4.00±.00[a]	5.17±3.43
NSPC	Beneficiary	1.49±.6[a]	1.5±.56[b]	1.50±0.0[b]	1.5±0.38
	None beneficiary	1.3±0.49[a]	1.24±0.5[a]	1.12±.65[a]	1.22±0.54

a-b means with the different superscripts under the same two consecutive column for the same breeds is significantly different at p<0.05, HFC=Holstein Frisian cross, JERC=Jersey cross), SD-standard deviation.

Table 8. Reproductive performance of dairy cows per breeds in the study districts in months (mean ±standard deviation)

Breeds	AFS	CI	LL	DO	NSPC
Native	41.5± 9.8[c]	21.72±4.51[b]	8.75±2.443[a]	7.51±2.527[c]	1.51±0.627[b]
HFC	32.9±7.76[b]	18.01±3.86[ab]	9.68±1.64[ab]	5.41±2.818[b]	1.41±0.86[b]
JERC	21.3±3.71[a]	16.90±4.878[a]	10.38±1.94[b]	4.14±2.372[a]	1.14±0.42[a]
Overall	35.35±10.45	19.22±4.500	9.48±1.984	6.07±2.902	1.35±0.63

a-b means with the different superscripts under the same column for the same parameter in different breed type is significantly different at p<0.05.AFS=age at first service, CI=calving interval, LL=lactation length,DO= days open, NSPC= numbers of service per conception HFC=Holstein Frisian cross, JERC=Jersey cross.

Table 9. Milk yield between OSMI beneficiary and none OSMI beneficiary per day in litter in the study areas (means± SD)

	Early		Mid		Late	
Breeds	Beneficiary	None beneficiary	Beneficiary	None beneficiary	Beneficiary	None beneficiary
Native	2.61±.1	2.5±1	1.5±.74	1.37±0.7	0.79±0.4	0.72±0.4
HFC	9±4.0[b]	7.64±4[a]	6.±2.1[b]	5.±3.0[a]	3.6±2.1	2.88±.2
JERC	5.±1.2[b]	3.4±.49[a]	3.2±.45[a]	2.08±.8[b]	1.80±.8	1.33±.82
Overall	5.54±2.1	4.5±1.83	3.6±1.1	2.82±1.5	2.1±1.1	1.64±0.473

a-b means with the different superscripts under the same two consecutive column for the same breeds is significantly different at p<0.05,JERC= Jersey cross, HFC=Holstein Frisian, HHFC, higher Holstein Frisian (>75% blood level).

 DOI: http://dx.doi.org/10.36956/njas.v4i1.391

4.5 Factor Affecting Reproductive Performance of Dairy Cow

Factor affecting reproductive performance of dairy cows in the study area was presented in Table 10.The current survey result showed that 49.6% of respondents agreed that management is the main factor that influences reproductive performance and 34.1% of respondents were agreed feed is the other limiting factor on reproductive performance followed by genotype (13.8%) and disease (2.5%) in the study areas.

4.6 Constraints that Limit Farmers to Participate in OSMI Program

The findings as indicated in Table 11 indicate the constraints associated with why farmers involved in OSMI Program are manifold. The respondents from B district have indicated that there was no strict follow up, Lack of training (awareness) about OSMI and also that the inseminator was unwilling to come over to the farmers doorstep. The respondents from S district opined that the lack of improved genotypes, Lack of training (awareness) about OSMI and also Lack of AIT of the cattle reared in the area. This is all the more important as the OSMI program coincided with the dry season when the quality and quantity of the feed was compromising. The findings pertaining to A district indicate that the major constraints are Lack of training (awareness) about OSMI and also no strict follow up of the synchronization program.

5. Discussion

5.1 Household Demography

The results pertaining to the educational status and ratio of land holding to family size of the respondents are presented in Table 1. The study further indicated that most of the respondents had only basic education and very few of them have education beyond the secondary schooling, these observations too are in close accordance with those of [16-18]. However findings have indicated that most of the respondents were illiterate with very few of them who were able to read and write which impairs them from maintaining proper records at their farm [19]. Thus they are mostly dependent on recall method which in most of the cases inaccurate [20,21]. The extension agents' stakeholders are expected to develop proper extension manuals and recording systems which are user friendly for all sections of the livestock rearers. The study further indicates that the overall land holding per family size was very low in across all districts. So the respondents should be changed from cropping farming system to livestock production system.

5.2 Total Herd Size Per Household and Per Breed

The findings from Table 2 show that the overall heard size of the native cattle are in close agreement with those of [22] from North Gondar. However, the numbers are lower than those reported by [23] from North Gonder. The lower numbers of native cattle as observed may be to

Table 10. Perception of farmers on the Factors affecting reproductive performance of dairy cow per districts in (%).

	Districts			
	Basonaworena	Siyadebrnawyu	Angolelanatera	Overall
Feed	35.6	31	35.6	34.1
Genotype	14	11.8	15.6	13.8
Management	46.7	57.1	45.1	49.6
Disease	3.7	0.1	3.7	2.5

Table 11. Constraints that why not farmers participate in OSMI Program (N=135)

Why not you participate in OSMI program	**Districts**			
	Basona worena%	Siyadebrnawayu%	Angolelanatera%	overall
Lack of AIT	16.7	19.3	5.6	13.87
Lack of improved breed for this service	0.0	24	4.4	9.467
Lack of training(awareness) about OSMI	24.4	20.0	23.3	22.57
Unwillingness of AITs to come	18.9	6.7	5.6	10.4
No strictly follow up	20.0	22.2	23.6	21.93
Long distance of inseminate center	1.1	0.0	5.4	2.167
lackof concentrate feed	10.0	0.0	18.4	9.466

OSMI=estrus synchronization mass insemination, N= number of respondents in the three districts.

DOI: http://dx.doi.org/10.36956/njas.v4i1.391

the fact that the respondents prefer the crossbred cattle over the native cattle; the findings are in close agreement with those of [24]. The proportionately higher numbers of crossbred cattle in the study areas may be because the respondents have at their disposal good amount of crop residues which can ensure better nutritional availability the year around. The study further indicates that higher proportion of Holstein Friesian and Jersey crossbreds, which too is in accordance with the observations of [25,24,16]. The higher proportion of crossbreds indicates the presence of a good artificial insemination system in the area. The fewer numbers of HHFC i.e higher blood levels of Holstein Friesian crossbreds indicate that either these crossbreds do not perform well in the prevailing agro ecology or the farmers are not aware of their management practices , the observations are in close accordance with those of [26] from Debre Zeit. Studies by [27] have indicated that in the tropical environment the higher blood levels of exotic cattle suffer from tropical degeneration and therefore such cattle rarely perform better than the F_1 crossbreds. These observations are in close consonance with the findings of [28,29].

5.3 Management Practice of Dairy Cows

5.3.1 Feed Resources

The feed resources available in the study areas are presented in Table 4 the study indicates that feed availability is not a problem for most of the respondents. This may be attributable to the availability of crop residues. These findings are in close accordance with the reports of [30]. The observation regarding the use of crop residues as a source of fodder too has been reported by [31,30] from high land parts of the country. The use of oats and vetch as a source of fodder to find consonance with the observations of [25]. However, it's not only the availability of the feed that matters but providing a balanced diet to the pregnant and lactating cow is imperative for ensuring an overall productivity and the economics of a cattle [25]. Thus, the respondents need to be made aware of the intricacies of balancing the feed for different genotypes and classes of cattle. Therefore, the livestock extension agents need to demonstrate the respondents as to how to develop a balanced diet using locally available feed resources. This in one way is expected to meet the nutritional requirements of the cattle but also can help in utilization of locally available resources and also recycling of nutrients.

5.3.2 Source of Water during Dry and Wet Seasons

The findings show that most of the respondents in the areas used various sources of water viz. river, pond, tap and well, the observations are in close accordance with those of [32,25] from Fogera Wodera Amhara region and high land of Ethiopia in respectively. Clean water is important for all physiological processes. However, the usages of each source varied across the locations. It was observed that river water was the most commonly used source across all the studied locations especially during the dry season. These findings are in accordance with the observation of [25] from high land of Ethiopia. While, the presence of nearby river ensures that the water is available the year round, however the water may also be contaminated from parasites and diseases upstream and mayalso pass on the same to animals which use the same source downstream [20]. Moreover contamination from faeces, urine and other exogenous wastes can also influence the productivity of the livestock using the source downstream. The usage of pond water too was reported by many of the respondents, which too is in close accordance with those of [33]. The usages of pond water too have to be done with care and separate space has to be provided for the sick and infirm animals to prevent spread of diseases [34]. The study also indicates that no separate watering space is provided to the cattle which are in close accordance with those of [35]. Separate watering space is to be provided to the cattle as a part of good husbandry practice and also the respondents need to be appraised about clean water and waterier and its benefit on the health of the animals as a whole. The livestock extension agents need to appraise the respondents about construction of proper mangers using locally available materials. They should also be informed about the cleaning process of the same and importance of clean and safe drinking water.

5.3.3 Housing of Cattle in the Study Areas

Providing proper housing for the cattle is one of the most important husbandry practices which are needed to protect the animals against the vagaries of nature and thefts and predators alike [36]. Housing has to be so provided that it is well ventilated and well drained [16]. The housing of livestock should be such that it is comfortable and prepared to suit the local climatic condition and prepared from locally available materials. The study indicates that in most of the cases the houses are prepared from stones (floor and walls) and thatched, while stone floor can at times be slippery and may not be able to provide adequate cushioning for the animals housed. The crevices between the stones are difficult to clean and

 DOI: http://dx.doi.org/10.36956/njas.v4i1.391

can be a potential source of infection [37]. Therefore, the respondents need to be appraised about cementing the crevices and also proper drainage. The roofs are mostly thatched can be prone to fire and allied hazards besides they can also house different predators and vermin's. It has been observed in several studies that if a livestock is housed comfortably their production and reproduction ability is improved manifold [26]. However, the housing has to be such that it suits the prevailing agro climatic conditions of the area besides proving comfort to the animals themselves.

The study also indicates that in many cases the cattle are not housed separately, which again is one of the greatest drawbacks, as it can lead to impairment in productivity and also does not provide the privacy desired for parturition. Studies have also indicated that cases of abortion are higher among the cattle housed together with other livestock or different ages of cattle as butting by the bulls or steers [38]. Care has to be taken so as to provide adequate ventilation in the cattle house so as to lower the production of ammonia in the house. Studies by [39] have indicated that higher amount of ammonia in livestock houses can impair the productivity and also is uncomfortable for the handlers.

5.3.4 Common Dairy Cow Disease

The results pertaining to the disease incidences among the livestock indicate the prevalence of foot and mouth disease (FMD) in the herd, the observations are in close accordance with those of [40] from Oromia Region and FMD is a vaccine preventable disease hence the respondents need to be made aware of the same [41]. Care of the infected cattle too needs to be understood and hence the livestock extension agent needs to be proactive in these cases and teach the preliminary veterinary care for the infected livestock [41]. It was also reported that mastitis is also another disease of economic importance and can be prevented following proper hygiene [41]. The respondents need to be trained about udder care and management by the extension agent besides the use of teat dipping has to be promoted by the respondents. Studies have indicated that the economic losses due to mastitis can be substantial and can account for more than 11024 million Birr annually [42] in the US.

5.3.5 Reasons of Culling Cattle

The findings as presented in Table 7 show that the major reason for culling cattle are for fulfilling financial requirements of the family (in B district). This is in consonance with the observations of [43] from Zimbabwe. However, studies by [44] have indicated that bovines are sold only in the dire consequences by the farmers and it's the small ruminants which are sold off first. It may be that the respondents sell of their excess cattle for income generation, these amounts to the sale of the male animals, barren cows and also at times heifers [45,46]. The utilization of cattle for beef purposes may also be ascribed to the use of male animals as a source of beef for the family and the neighbours. These observations are in close accordance with those of [46]. Poor production and body conditions too were considered as criteria for culling of cattle, which may be ascribed to the economics of rearing the cattle [44]. Cattle with poor body condition are usually the ones that are culled first as they are economically unviable to rear [44].

The study also indicates that most of the respondents avail the facilities of the government veterinary clinic which too is in agreement with those of [47]. The findings also show that most of the veterinary facilities are situated within 5 km from the respondents residence, which is also in close accordance with the findings of [48] from Bench Maji zone South West parts of Ethiopia. Well-equipped veterinary facilities need to be in place when the crossbred cattle are reared as the crossbred are prone to tropical diseases [49]. It has also been observed that establishment of Para veterinary clinics too need to be established within the kebeles so that proper veterinary care can be made available to the crossbreds, this can also serve as employment opportunities of veterinary or ATVET graduates and thereby arrest migration to the urban areas.

5.4 Reproductive Performance of Cattle Reared by the Beneficiary and Non-beneficiary of OSMI and Per Breed

The results from Table 7 were indicative that the reproductive functions of the cattle reared by the participants were better than those of the non-participants. This may be because the participants were selected based on their experience of cattle husbandry. It may also be ascribed to several rounds of trainings that the participants had received during the course of the project. The results pertaining to the influence of genotypes on the milk production traits indicate that the AFS, CI, and DO was lower in the native cattle when compared to the HFC and HHFC which too is in close agreement with the findings of [50]. This may also be ascribed to the genetic makeup of the native cattle and partially due to the fact that the farmers usually provide some sort of preferential treatment to the crossbreds.

DOI: http://dx.doi.org/10.36956/njas.v4i1.391

5.5 Milk Yield between Beneficiary and None Beneficiary of OSMI

The findings as presented in Table 9 indicate that there were differences ($P<0.05$) across the milk yield of the cattle raised by the participants of OSMI project in comparison those reared by the non-participants. This may be ascribed to the fact that the participants were selected based on some predefined traits such as experience in rearing cattle Studies by [51] have also indicated that rearers well experienced in rearing cattle usually understand the nutritional and husbandry requirements better than the beginner. The differences may be also ascribed to the trainings received by the participants pertaining to scientific cattle husbandry practices [51].

5.6 Factor Affecting Reproductive Performance of Dairy Cow

The findings as indicated in Table 10, is indicative of the reproductive performance of the cattle in the areas studied are grossly influenced by management of the cattle followed by the nutrition of the cattle. The findings are in close accordance with the reports of [9]. Management of the cattle influences the growth of the cattle and thereby their reproduction [52,53]. Besides the same, cattle receiving poor nutrition both in quality and quantity will impair the development of the reproductive organs [52]. Studies by [54] have also indicated that poor nutrition of livestock can also influence the hormonal functions of the cattle and thereafter the reproduction function. Studies have also indicated that while native cattle are able to utilize poor quality forage better than the crossbred cattle [55].

5.7 Constraints that Why not Farmers Participate in OSMI Program

According to the respondents during the study period, there were a lot of obstacles farmers why not participate in OSMI Program, in the study areas which include but not limited to these; lack of AIT, improved breed for this service, training (awareness) about OSMI and unwillingness of AITs to come, no strictly follow up.

6. Conclusions

Natural pasture and crop residue were the most common feed resources in the study areas. River water was the major source of water for their cattle and well water was used when river water is not available. In their order of importance; FMD, mastitis, and abortion were the major diseases of cattle in the study area.

The results indicated that the reproductive performance of the cattle reared by the participants were better than those of the non-participants. There was significant ($p<0.05$) difference in milk yield between beneficiary and none beneficiary in HFC, HHFC and JERC dairy cows per day per cows.

In North Shewa zone starting 2013/14 up to 2015/16 there are some problems identified in OSMI such as no strict follow up after synchronized, AIT only depend on the 3rd days, after hormone injection Poor body condition cow, provide non-cycling cows, heat detection problems and pass insemination time. There was a significance difference between breed in reproductive performance across the three breed.

7. Recommendations

❖ Creation of farmers' awareness in the study area, on managerial as well as breeding aspects create an opportunity in improving breeding and management practice of dairy cattle and also it avoids misunderstanding of different managerial aspects which are practiced by farmers traditionally.

❖ Participatory and sustainable breeding strategy could be undertaken through incorporating indigenous knowledge of farmers and by including training of the dairy owners to improve productivity of dairying.

❖ To improve efficiency of dairy cattle productivity and reproductivity, improving oestrus detection method, proper time of insemination, good management practice, proper semen handling, full inseminator equipment etc must be considered.

❖ To inter farmers in the OSMI program create awareness about advantage of OSMI and strictly followup.

Authors' Contributions

Sharew Mekonnen performed the whole part of the research.

Belete kuraz and Dr.Mulugeta Tesfaye commented, edited and guidance of the research. All authors read and approved the final manuscript.

Availability of Data and Materials

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

References

[1] Rasby & Gene Deutche, 2013. Synchronizing Estrus in Beef Cattle.University of Nebraska–Lincoln | Lincoln, NE 68588 | 402:472-7211.

[2] IAARD-IJAVS (International Journal of Agriculture

 DOI: http://dx.doi.org/10.36956/njas.v4i1.391

and Veterinary Sciences), 2015. The Status of Oestrus Synchronization and Conception Rate in Ethiopian Cattle Breed 1:19-26.

[3] Azage Tegegne, Dirk Hoekstra, Berhanu Gebremedhin and Solomon Gizaw, 2016. International Livestock Research Institute (ILRI) February.

[4] Azage Tegegne, Tesfu Kassa, Mukasa-Mugerw E., 2015. Aspects of bull production with emphasis on cattle in Ethiopia. Sperm production capacity and semen characteristics. In: Proceeding of the Third National Conference of Ethiopian Society of Animal production, pp. 83-99.

[5] Kefyalew Alemayehu & Addis Getu, 2015. the Status of estrus synchronization and conception rate in Ethiopian cattle International Journal of Agriculture and Veterinary Sciences, 1:19-26.

[6] Hopkins F. & Schrick F.n.d., 2013. Estrous.s ynchronization. ebookpp. 1Available through2. :http://animal science. ag. utk. edu /dairy /Publications dairy. htmlh/ Estrous Synchronization-FMH.pdf.

[7] Walker W. L., Nebel, R. L. & Mc Gillard M. L., 1996. Time of ovulation relative to mounting activity in dairy cattle. J. Dairy Sci. 79: 1555-1561.

[8] Hansar E., Lemma A. & Yilma T., 2014. Pre-service ultrasonic and manual evaluation of the reproductive organs of dairy cows presumed to be in oestrus. Springer Plus 3: 529.

[9] Shiferaw T. Bekana M., Kasa Y. & Tenhagen B.A., 2003. Reproductive performance of crossbred dairy cows in different production systems in the central highlands of Ethiopia. Tropical Animal Health Prod. 25:551-561. Clinical and practical aspects. Theriogenology, 74: 327-344.

[10] Gebeyehu Goshu, Belihu Kelay and Abebe Berihun, 2007. Effect of parity, season and year on reproductive performance and herd life of Friesian cows at Stella private dairy farm, Ethiopia. Livestock Research for Rural Development 19 2007.Janu 2018.

[11] Habtamu Lemma, Behailu Kelay & Shiferaw Desie, 2010. Study on the reproductive performance of Jersey cows at Wolaita Sodo dairy farm, Southern Ethiopia. Ethiop. 14 : 53-70.

[12] Gebregziabher, 2003. Assessment and Comparison of Sex Ratio Following Artificial Insemination and Natural Mating in Small Scale and Modern Dairy Cattle Farms in Mekelle 5,: pp:58-64.

[13] Mekonnen Tadesse, Merga Bekana, Abayneh Temesgen., 2010. Reproductive performance and efficiency of artificial insemination smallholder dairy cows/ heifersin and around Arsi-Negelle, Ethiopia. Livestock Research for Rural Development, 22.

[14] Perez G. A., M. F. Smith, M. C. Lucy, J. A. Green, T. E. Parks, M. D. Macneil, A. J. Roberts, and T. W. Geary., 2012. Relationship between follicle size at insemination and pregnancy success. Proc. Natl. Acad. Sci. U.S. A. 102: 5268-5273.

[15] BoZLFDR, 2015. Beruea of zonal livestock and fishery department report.

[16] LeeKim., December 2014. The major reproductive problems of dairy cows in and around asella town, central Ethiopia. Vol. 1 (4), pp. 073-077. Available online at www.advancedscholarsjournals.org.

[17] Assemu Tesfa, Dilip Kumar, Solomon Abegaz, Getinet Mekuriaw, Tewodross Bimerew, Adebabay Kebede, Addisu Bitew, Yeshewas Ferede, Hailu Mazengia and Mekonnen Tilahun, 2016. Growth and reproductive performance of Fogera cattle breed at Andassa Livestock Research Center.

[18] Melku Muluye, 2016. Milk production and reproductive performance of local and crossbreed dairy cows in selected Districts of west gojam zone, amhara region, ethiopia M.Sc. Thesis.

[19] Tsegaye S, Tesfaye C, 2002. Experience on field AI management in Ethiopia. Livestock in Food Security Roles and Contributions. Proceedings of 9th annual conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, Ethiopia, August 30-31, 2001. ESAP (Ethiopian Soc. Anim. Prod.), pp. 433.

[20] Destalem,Gebremedihn., Belay & Azage Tegegne, 2015. Assessment of Breeding Practice of Dairy Cattle in Central Zone of Tigray, Northern Ethiopia. Journal of Biology, 5(23).

[21] Karume Semfuko chaussa, 2013. Assessment of factors affecting performance of dairy cattle kept in smallholder farms in peri-urban areas of temeke municipality Tanzania PhD dissertation.

[22] Addisu Hailu, Melese Abate, 2016. Community breeding practice and the challenges in dairy cattle management in North Gondar, Ethiopia International Journal of Environmental & Agriculture Research. ISSN, 2:2454-1850.

[23] Azage Tegegne, Desalegn G/Medhin, Merga Bekana and Kelay Belihu, 2009. Status of artificial insemination service in Ethiopia. In the 17th Annual Conference of the Ethiopian Society of Animal Production (ESAP), Sept 24-26, 2009 Addis Ababa, Ethiopia, PP.87-104.

[24] Belay Duguma & Geert Paul Jules Janssens, 2016. Smallholder dairy farmers' breed and cow trait preferences and production objective in Jimma town, Ethiopia.

DOI: http://dx.doi.org/10.36956/njas.v4i1.391

DOI: http://dx.doi.org/10.5829 / idosi.ejbs. 8.01.10385.

[25] Zewdie Wondatir, 2010. Livestock production systems in relation with feed availability in the highlands and central rift valley of Ethiopia. M.Sc Thesis, Haramaya University, Ethiopia.

[26] Million Tadesse and Tadelle Dessie, 2013. Effect of non genetic factors on milk production traits of pure jersey dairy cattle I centeral highland of Ethiopia.

[27] Madalena F.E., Lemos A.M., Teodoro R.L., Barbosa R.T. and Monteiro J.B.N., 1990a. Dairy production and reproduction in Holstein–Friesian and Guzura crosses. Journal of Dairy Science 73:1872-1886.

[28] Kiwuwa G H, Trail J C M, Kurtu M Y, Worku G, Anderson F and Durkin J., 1983. Crossbreed dairy cattle productivity in Arsi region, Ethiopia. ILCA Research Report 11. International Livestock Centre for Africa 1-29.

[29] Million Tadesse and Tadelle Dessie, 2003. Milk production performance of Zebu, Holstein Friesian and their crosses in Ethiopia. Livestock Research for Rural Development. Volume 15, Article #26. Retrieved March 11, 2018, from http://www.lrrd.org/lrrd15/3/Tade153.htm.

[30] Endale Yadessa, 2015. Assessment of feed resources and determination of mineral status of livestock feed in meta robi district,west shewa zone, oromia regional state, Ethiopia msc. Thesis Ethiopia.

[31] Desta K.B., 2002. Analyses of Dairy Cattle Breeding Practices in Selected Areas of Ethiopia. PhD Thesis Humboldt-Universitat Berlin, 2-123.

[32] Belete Anteneh, Azage Tegegne, Fekadu Beyene and Berhanu Gebremedhin, 2010. Cattle milk and meat production and marketing systems and opportunities for market-orientation in Fogera woreda, Amhara region, Ethiopia. IPMS (Improving Productivity and Market Success) of Ethiopian Farmers Project Working Paper 19. ILRI (International Livestock Research Institute), Nairobi, Kenya. 65 pp.

[33] Alemshet Birhanemeskel and Weldegerima Kide, June 2018. Participatory Evaluation of Artifcial Insemination (AI) Service IAEB: 11(3): 589-595. Delivery and Semen Quality in Northern Ethiopia

[34] Amenu kebede, 2013. Perceived role of container smoking in milk hygiene and safety: Results of qualitative exploratory study in Borana, Ethiopia.

[35] Tesfaye, Y., Roos, A., Campbell, B.M. and Bohlin, F., 2011. Livelihood strategies and the role of cattle income in participatory-managed forests of Dodola area in the bale highlands, southern Ethiopia. Cattle policy and economics, *13*, pp.258-265.

[36] Teshome Kidanie, Dessalegn, Endeshaw Terefe, Ashebir Kifle, Abebe Tafa, Weldegebrial G. Aregawi, Workinesh Seid & Woldegebriel T/ Mariam, 2016. Cattle management and marketing practices in Afar region, 7:55-65.

[37] Elmore M. R. P., Elischer M. F., Claeys M. C and Pajor E. A., 2015. The effects of different flooring typeson the behavior, health, and welfare of finishing beef steers. Department of Animal Sciences, Center for Food Animal Well-Being, Purdue University, West Lafayette, IN 47907-2042.

[38] Harouna, Dec 16 2013. Seroprevalence and potential risk factor for brusella spp.infection in Niger.

[39] Rotz, C.A., 2004. Management to reduce nitrogen losses in animal production 1. Journal of animal science, 82(13_suppl), pp.E119-E137.

[40] Workneh, Ayalew and J. Rowlands, 2013. Design and execution and analysis of livestock breed survey in Oromiya regional state, Ethiopia. OADIS (Oromia ILRI (International Livestock Research Institute), Nairobi, Kenya. pp: 260.

[41] OIE, 2009. Foot-and-mouth disease. In: Mannual of standards for Diagnostic Tests and Vaccines for Terrestrial Animals 6T Edn. Paris, OIE, http/www.oie.int/eng/norms/mannual-2018-pdf/2.01.01 FMD.pdf.

[42] Janzen, J. J., 1970. Economic Losses Resulting from Mastitis. A Review1. Journal of Dairy Science, 53(9), 1151-1160.

[43] Barrett, J.C., Brinn, P. and Timberlake, J., 1991. Tsetse control, agropastoralism and land degradation: a case study in Chiswiti Communal Land. Final report. *Unpublished* report of the Tsetse and Trypanosomiasis Control Branch, Department of Veterinary Services: Harare.

[44] Godadaw Misiganaw, Zewdu Wuletaw. and Workneh Ayalew, 2014. Breeding practices in indigenous dairy cattle breeds in Northern Amhara, Ethiopia. Livestock Research for Rural Development. Volume 26, Article #62. Retrieved April 1, 2016, from http://www.lrrd.org/lrrd26/4/misg26062.htm

[45] Azage Tegegne, 1989. Reproductive Development and Function in Zebu and Crossbred Cattle in Ethiopia. Ph.D. Thesis, James Cook University, Australia.

[46] Jeroen D. Joachim and Ugo pica C, 2007. Pro-Poor Livestock Policy Initiative A Living from Livestock Pro-Poor Livestock Sector Development in Latin America: A Policy Overview. [47] Bahlibi Weldegebriall, 2015. Assessment of major reproductive problems of dairy cattle In selected sites of central zone of tigrai region, northern Ethopia. Msc.thesis Submitted to the College of Veterinary Medicine, Mekelle University, Mekelle, Ethiopia.

[48] Tegegn Fantahun and Zelalem Admasu, January 2017. Evaluation of oestrus synchronization and mass artificial insemination service of dairy cattle in Mizan Aman area, Bench Maji zone, South West Ethiopia Vol. 8(1), pp. 1-4.
DOI: http://dx.doi.org/10.5897/IJLP2016.0338.

[49] Singh S.P., 2011, Crossbreedingthe importance ofbeingIndigenous.http://farmersforum.in/agriculture-farming-india/crossbreeding-the importance-of being-indigenous/ (accessed on 10.10.2018).

[50] Galukande G.E., 2010. Comparison of production systems with purebred Ankole vs crossbredAnkole-Frisian animals on-farm using a combined cross-sectional and longitudinal approach (Kiruhura District of Uganda). PhD thesis University of Natural resources and Life Sciences Vienna, 6-63.

[51] Ahmed M. Bezabih Emana Jabbar, F. Tangka and S. Ehui, 2017. Economic and nutritional impacts of market-oriented dairy production in the Ethiopian highlands.

[52] Roche, J.F., 2006. The effect of nutritional management of the dairy cow on reproductive efficiency. Animal reproduction science, 96, pp.282-296.

[53] Santos, J.E.P., Juchem, S.O., Cerri, R.L.A., Galvao, K.N., Chebel, R.C., Thatcher, W.W., Dei, C.S. and Bilby, C.R., 2004. Effect of bST and reproductive management on reproductive performance of Holstein dairy cows. Journal of dairy science, 87(4), pp.868-881.

[54] Lucy, M.C., 2008. Functional differences in the growth hormone and insulin−like growth factor axis in cattle and pigs: implications for post−partum nutrition and reproduction. Reproduction in Domestic Animals, 43(s2), pp.31-39.

[55] Hansen, P.J., 2004. Physiological and cellular adaptations of zebu cattle to thermal stress. Animal reproduction science, 82, pp.349-360.

Abbrevations

AFS	Age at first service
AI	Artificial insemination
AITs	Artificial insemination technician
DO	Days open
CI	Calving interval
LL	Lactation length
NSPC	Number of service per conception
OSMI	Oestrus synchronization and mass insemination

NASS Journal of Agricultural Sciences
http://ojs.nassg.org/index.php/NJAS

Performance of Common Reed (*Phragmites australis*) in a Constructed Wetland for Greywater Treatment in Akure, Nigeria

Alao, F.[1*] Alatise, M. O.[1] Olanrewaju O.O.[1] Oloruntade, A. J.[2]

1. Department of Agricultural and Environmental Engineering, Federal University of Technology, Akure, Nigeria
2. Department of Civil Engineering, Olusegun Agagu University of Science and Technology, Okitipupa, Nigeria

ARTICLE INFO

Article history
Received: 15 November 2021
Accepted: 14 December 2021
Published Online: 24 December 2021

Keywords:
Biochemical oxygen demand
Common reed
Constructed wetland
Greywater
Heavy metals
Salinity

ABSTRACT

Shortage of freshwater is becoming a growing problem in both dry and semi-dry regions of the world, hence the need to make use of other source of water for agricultural production. The study was conducted to examine the performance of common reed in a constructed wetland for greywater treatment in Akure, Nigeria. Raw greywater was collected from Jadesola Hostel, Federal University of Technology, Akure, and pretreated through a combination of gravel of diameters < 32 mm, 24 mm and 16 mm with fine sand of diameter 0.2 mm arranged accordingly. The filtered water was thereafter released to a plastic constructed wetland (CW) which also consisted of same combination of layers of gravel and sand with common reed planted on it for complete treatment. The raw and treated greywater were analyzed for Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Dissolved Solid (TDS), and heavy metals. It was discovered that CW planted with common reed was effective in the treatment of greywater with reduction in BOD by 91.4%, COD by 91.5% and TDS by 38.7%. CW had appreciable removal effect on heavy metals with reduction in: manganese (Mn) from 0.100 ppm to 0.012 ppm, iron (Fe) from 0.014 ppm to 0.002 ppm, lead (Pb) from 0.05 ppm to 0.001 ppm and zinc (Zn) from 0.154 ppm to 0.148 ppm. Therefore, the use of common reed in constructed wetland for greywater treatment is recommended for farmers involved in irrigation with greywater, especially during dry seasons, and most importantly under the rising global water scarcity due to climate change.

1. Introduction

Owing to endlessly growing population, enormous bulk of domestic wastewater is being formed in cities. Undiscriminating dumping of such water causes pollution of air, soil and groundwater supplies. Rivalry for freshwater among different water-use parts already exists in several arid and semi-arid regions, causing dwindled distribution of freshwater to agriculture. For this reason, declining supplies of water quality for irrigation and growing demand from other handlers are forcing farmers to use non-conventional water resources [1]. Amongst these various non-conventional sources, the use of treated wastewater (TWW) has taken on greater significance. Indeed, this quality of water for agriculture offers the greatest scope for application because it usually has the potential to meet growing water demands, conserve potable supplies, reduce disposal of pollution effluent into

**Corresponding Author:*
Alao, F.,
Department of Agricultural and Environmental Engineering, Federal University of Technology, Akure, Nigeria;
Email: femmylaoo@gmail.com; femmylao@yahoo.com

 DOI: http://dx.doi.org/10.36956/njas.v4i1.455

surface water bodies, allow lower treatment costs and enhance the economic benefits for growers due to reduced application rates for fertilizer [2].

Greywater refers to all wastewater that is discharged from a house, without blackwater (toilet water). This includes water from showers, bathtubs, sinks, kitchen, dishwashers, laundry tubs, and washing machines [3]. It commonly contains soap, shampoo, toothpaste, food scraps, cooking oils, detergents and hair. Greywater makes up the biggest proportion of the total wastewater flow from households in terms of volume [4]. Typically, 50-80% of the household wastewater is greywater. If a composting toilet is also used, then 100% of the household wastewater is greywater. Greywater is a replication of the household activities and its characteristics are strongly dependent on living standards, social and cultural habits, number of household members and the use of household chemicals [5]. Greywater from bathtubs, showers and hand-wash basins is considered as the least polluted greywater source [6]. The average greywater contribution to the total organic load (BOD_5) amounts to about 40 – 50%. Greywater also contributes to one fourth of the total suspended solids and up to two thirds of the total phosphorous load.

Despite the foregoing, the usage of greywater for agricultural irrigation purposes has become a common practice globally, because of water shortage and population growth [7]. The treated greywater can be supplied for irrigation of indoor plants as the greywater is most suitable for this purpose. The treated greywater can also be used for irrigating agricultural crops and turfs and for maintaining decorative fountains or landscape impoundments. However, such applications must meet the strict requirements from possible exposures to greywater. This suggests that reclaim of greywater for irrigation purposes must follow the attainment of certain levels of treatment. One common, but efficient way of achieving such a requirement is through the use of constructed wetlands (CW). Constructed wetlands are engineered systems intended to exploit natural processes for water quality developments. They perform this function by eliminating contaminants in wastewaters through a mixture of physical (filtration, sedimentation), biological (microbial processes, plant uptake) and chemical (precipitation, adsorption) mechanisms. They naturally have impermeable clay or synthetic liners, and engineered structures to control the flow direction, liquid confinement time and water level. Depending on the type of system, they may or may not contain an inert porous media such as rock, gravel or sand. In constructed wetlands, vegetation plays an incomplete part during the treatment process, because it helps in providing oxygen to the microorganisms in the rhizosphere, decrease the volume of nutrients in the system by uptake and perhaps provide more surface area in the rhizosphere for the microorganisms Constructed wetlands are classified as either Free Water Surface (FWS) systems or Subsurface Flow (SSF) systems. Any wetland, in which the surface of the water flowing through the system is exposed to the atmosphere, is classified as FWS system. In SSF systems water is designed to flow through a granular media, without coming into contact with the atmosphere.

Different researchers have investigated the wide use of constructed wetland for different types of wastewater, including domestic [8,9], industrial [10,11], agricultural runoff [12], dairy [13] and polluted river water [14,15]. In all these applications, significant improvements in water quality were reported. In spite of the wide suitability of the success of constructed wetlands for the treatment of variations of wastewater [9,16], information is scarce in the literature as regards the use of the technique in Nigeria. Thus, the need for a research with a focus in this particular area of wastewater management cannot be over-emphasised.

Likewise, bearing in mind that different macrophytes plants are used in constructed wetland (CW) to attain the numerous requisite treatment levels [17], it has become imperative to assess the specific performance of the varieties of macrophytes. This is very important, because studies have shown that the performance of macrophytes varies under hypertrophic waterlogged conditions, local climate, pests, diseases and pollutants [16]. Moreover, for a satisfactory performance, plants must be readily propagated, establish easily, and spread and grow rapidly [18]. In addition, they must exhibit a high pollutant removal capacity, either through direct assimilation and storage, or indirectly by enhancement of microbial transformations such as nitrification (via root-zone oxygen release) and denitrification (via production of carbon substrates) [18]. Currently, the most frequently used plants in CW are common reed (*Phragmites australis*), rushes *(Juncus spp.*), bulrushes *(Scirpus spp.),* narrow-leaved cattail *(Typha angustifolia L.),* broad-leaved cattail *(Typha latifolia L.),* yellow flag *(Iris pseudacorus L.),* sweet flag (*Acorus calamus L.)* and reed grass *(Glyceria maxima)*. However, of all the afore-mentioned plants, the use of common reed seems most prevalent amongst researchers, because it can be found almost in all parts of the world [19-21]. Reed plant can be found across the globe except in Antarctica, but its main dispersal area is Europe, the Middle East and America [22]. Moreover, the plant is extremely prolific grass with an above-ground net primary production ranging from less than 3 t ha^{-1} y^{-1} to as much

DOI: http://dx.doi.org/10.36956/njas.v4i1.455

as 30 t ha^{-1} y^{-1} [23]. *Phragmites australis* is one of the most commonly circulated wetland plant worldwide. Reed grass is an emergent perennial, herbaceous and flood-tolerant grass that is widely spread through tropical Africa as well as tropical and subtropical area of New Guinea, Australia and the Pacific. However, despite the widespread use of common reed in CW technology for greywater treatment around the world, to the best of our knowledge, its performance with respect to studies in Nigeria, is rare in the literature. Therefore, the aim of the present study was to investigate the performance of common reed in a constructed wetland for greywater treatment in Akure, Nigeria.

2. Materials and Methods

The study was carried out at the Experimental Farm located behind Jadesola Female Hostel, Obanla Campus of the Federal University of Technology, Akure (FUTA), Nigeria. FUTA is located in Akure which lies on Latitude 7°14' N and Longitude 5°08' E. The city is noted for its heavy rainfall with climate following the usual tropical pattern. The climate is humid with a rainy season which usually commences in March/April and ceases around October/November, while the dry season is from November to February or March. Mean annual rainfall varies between 1300 and 1600 mm and mean daily temperature is about 27.5 °C, with a relative humidity of about 58%. Akure is largely agrarian with common food crops including cocoyam, tomato, maize, plantain, and cash crops such as cocoa and timber commonly grown in the city.

Raw greywater (RGW) was sourced from the Jadesola Hostel (FUTA) of about 200 occupants. The RGW was drained to the experimental field through pipes of diameter 128 mm to an underground 500 litres water reservoir that served as a holding/sedimentation tank for the greywater. Pre-treatment of the collected RGW took place inside the 500 litres cylindrical plastic container, where food bits and other suspended objects (hair and lint) were sieved through stratums of gravels (diameters < 32 mm, 24 mm, and 16 mm) and a final layer of fine sand (diameter 0.2 mm), accordingly. The filtered RGW was released into the underground constructed wetland (CW) vertically through a pipe by gravity. The CW is a plastic container of surface diameter 1.5 m and depth 0.6 m. It also consisted of filters as in the sedimentation tank with common reed planted on it (Figure1). After retention time of two (2) days, the effluent from the wetland was assumed to have been treated and subsequently collected as treated greywater (TGW). Selection of the type of Constructed Wetland (CW) to develop depends on the pollutants the greywater is likely to contain, that is, Biological Oxygen Demand (BOD), Total Suspended Solids (TSS), heavy metals, and fats, oils and greases (FOG). The desired quality of effluent from CW would also determine the type of wetland to be developed. Thus, a Vertical Flow Constructed Wetland (VF-CW) was selected. A VF-CW has the ability to remove large amounts of BOD, remove nitrogen from the effluent (through anaerobic reactions), limit evaporation and water loss, and limits the surface area necessary for construction along with preventing possible safety hazards. The water types used were collected for water quality analysis.

Water is purified by reedbeds when entire reed stubbles start bacterial activity by carrying air (i.e. oxygen) to the roots *via* the aerenchyma. The retention time of the filtered greywater in the CW was calculated to be 2 days before being collected for analysis.

Samples of the RGW and treated greywater (TGW) were collected in two different 1 litre polyethylene bottles and analyzed. The used polyethylene bottles had been pre-washed with acid and distilled water and thereafter dried. The parameters determined were biochemical oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solid (TDS), manganese, iron, zinc and lead. The tests were carried out at the Chemistry and Analytical Laboratory of the University.

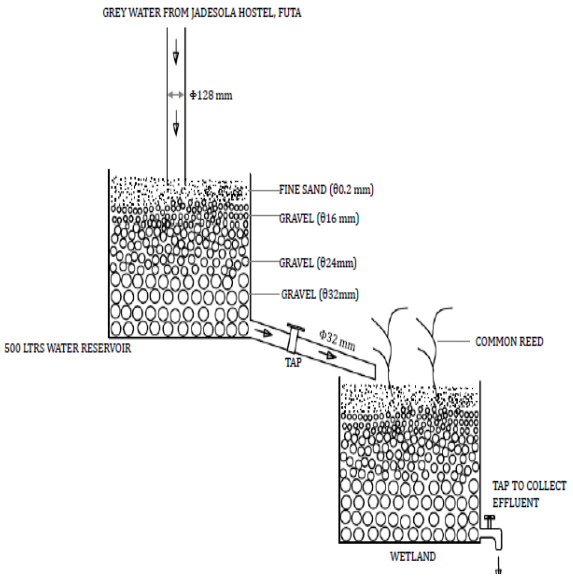


Figure 1. Greywater Treatment Setup

3. Results and Discussion

3.1 Wetland Performance

Pollutants removal efficiencies for biochemical oxygen

demand (BOD), chemical oxygen demand (COD) and total dissolved solid (TDS) were 90.92%, 91.46% and 38.73% (Table 1), respectively. These values are in conformity with Ridderstolpe (2004) [24], who reported 90 – 99% removal efficiencies for both BOD and COD. Previous report by Deguenon *et al.* (2013) [25] also showed that COD and BOD had removal efficiencies of 93% and 92%, respectively, when common reed was used to treat a campus domestic sewage. Similar report by Marzec *et al.* (2018) [26] showed that more than 95% of BOD and COD were removed in a tested hybrid CW system planted with common reed. Thus, the results of the present study show the high efficiency of common reed in the removal of large amounts of pollutants when used in CW. Meanwhile, the high removal efficiency of pollutants by the plant has been attributed to high oxygen transfer through the substrate media at which its vertical configuration promote better contact with microorganism and substrate aeration [27].

Further analysis of TGW showed slight to moderate salinity as TDS was 1226 mg/L and EC was 2.43 dS/m. Pescod (1992) [28] had recommended that wastewater for irrigation water should contain EC (0 - 2.0 dS/m) and TDS of the range 450 – 2000 mg/L (Table 1). On the contrary, the EC of the TGW was above the permissible limit, thus suggesting that irrigation with the TGW may cause slight to moderate problems of deterioration to the physical structure of the soil, which in turn may cause reduction in plant growth [29], root and shoot length and overall yield [30]. Nonetheless, combating this salinity is possible by applying more normal water than the plant needs to remove the salts from the root zone by leaching [31].

On the other round, results also showed that the TGW is suitable for irrigation given that both the BOD value of 24.50 mg/l and COD value of 35.51 mg/l (Table 1) are within the FAO acceptable levels [28]. Comparatively, the present results are similar to those of Bilha (2006) [32] and, Seswoya and Zainal (2010) [33] in their separate studies. The biochemical oxygen demand (BOD) and chemical oxygen demand (COD) levels in the TGW were low probably due to the pre-treatment that occurred in the sedimentation tank and low levels of degradable organic matter entering the CW systems.

3.2 Heavy Metals

The results of heavy metal analysis showed that their concentrations in TGW are in the WHO acceptable limits (Table 2) and, as such, the use of the TGW for irrigation may not have deleterious effects on both soil and crop. It should be noted that some heavy metals are essential to plant growth at low concentrations, but they become toxic and harmful at high concentrations. Our results further showed the removal efficiencies of Mn, Fe, Pb and Zn as 88%, 85.71, 98% and 3.90%, respectively. These removal efficiencies are in line with those of previous studies [34-40]. Meanwhile, efficient removal of heavy metals from wastewater has been attributed to the added rhizobacterium and adsorbents used in the CW systems [38,39]. In overall, heavy metals were predominantly removed through rhizofiltration, at which the metals were extracted from the wastewater through adsorption on the root. Following the adsorption through the root's membrane, the metals are either stored within the root itself or translocated to the other part of the plants where they undergo tissue localization [40].

Table 1. Pollutants removal efficiency of common reed in CW

Parameter	Raw Greywater	Treated Greywater	Removal efficiency (%)	FAO Standards (Pescod, 1992)
BOD (mg/l)	286.40	26.00	90.92	0.7 – 3.0
COD (mg/l)	415.77	35.51	91.46	450 – 2000
TDS (mg/l)	2001.00	1226.00	38.73	60
EC (dS/m)	4.02	2.26	43.78	200

Table 2. Concentrations of heavy metals in RGW and TGW

Element	Raw greywater	Treated Greywater	WHO limits (WHO, 1995) [41]
Fe (ppm)	0.014	0.002	0.300
Mn (ppm)	0.105	0.021	0.400
Pb (ppm)	0.050	0.001	0.010
Zn (ppm)	0.173	0.156	3.000

4. Conclusions

The research was conducted to investigate the performance of common reed in greywater treatment in Akure, Nigeria. First, we found a very high performance in the ability of common reed to remove pollutants from greywater when used in CW. Moreover, effectiveness of the CW was further emphasized as concentrations of heavy metals such as Mn, Fe, Pb and Zn were significantly reduced to permissible limits. In addition, both the BOD and COD of the TGW from CW fell within the standard limits, thereby confirming the suitability of the TGW for irrigation. These results are in conformity with previous studies, thus underscoring the effectiveness of constructed wetland (CW) in the treatment of greywater. However, the salinity of the TGW was slightly above the permissible limit, suggesting poor ability of the system to remove EC and, therefore the need for additional treatment measure. The foregoing notwithstanding, it

DOI: http://dx.doi.org/10.36956/njas.v4i1.455

was concluded that common reed has the potential to effectively treat greywater and its use in CW should by embraced. Nevertheless, further research is recommended to investigate the removal of salinity in RGW using CW and, the effects of the use of TGW for irrigation on soil properties and growth and yield of different varieties of vegetable.

References

[1] Shani, U., Dudley, L.M., 2001. Field studies of crop response to water and salt stress. Soil Science Society of America Journal. 65(5), 1522-1528.

[2] Paranychianakis, N.V., Angelakis, A.N., Leverenz, H., Tchobanoglous, G., 2006. Treatment of wastewater with slow rate systems: a review of treatment processes and plant functions. Critical Reviews in Environmental Science and Technology. 36(3), 187-259.

[3] UNDP, 2017. Sustainable development goals. Goal 6 targets facts and figures. http://www.undp.org/content/undp/en/home/sustainabledevelopment-goals/goal-6-clean-water and-sanitation/targets/. (Accessed 23/12/2018).

[4] Oron, G., Adel, M., Agmon, V., Friedler, E., Halperin, R., Leshem, E., Weinberg, D., 2014. Greywater use in Israel and worldwide: standards and prospects. Water research. 58, 92-101.

[5] De Gisi, S., Casella, P., Notarnicola, M., Farina, R., 2016. Grey water in buildings: a mini-review of guidelines, technologies and case studies. Civil Engineering and Environmental Systems. 33(1), 35-54.

[6] Bodnar, I., Szabolcsik, A., Baranyai, E., Uveges, A., Boros, N., 2014. Qualitative characterization of household greywater in the northern great plain region of Hungary. Environmental Engineering and Management Journal. 13(11), 2717-2724.

[7] Zipf, M.S., Pinheiro, I.G., Conegero, M.G., 2016. Simplified greywater treatment systems: Slow filters of sand and slate waste followed by granular activated carbon. Journal of Environmental Management. 176, 119-127.

[8] Kaseva, M., 2004. Performance of Subsurface flow Constructed Wetland in polishing Pre-treated water: A tropical case study. Journal Water Research. 38: 681 - 687.

[9] Joseph, K., 2005. Optimizing Processes for Biological Nitrogen Removal in Nakivubo Wetland, Uganda. Stocholm, Sweeden.

[10] Maine, M.A., Sune, N., Hadal, H., Sanchez, G., Bonetto, C., 2006. Nutrient and Metal Removal in a Constructed Wetland for Wastewater Treatment from a Metallurgic Industry. Ecological Engineering. 26, 341 - 347.

[11] Sohsalam, P., Sirianuntapiboon, S., 2008. Feasibility of using constructed wetland treatment for molasses wastewater treatment. Bioresource Technology. 99(13), 5610-5616.

[12] Forbes, E.G.A., Woods, V.B., Easson, D.L., 2004. Constructed Wetlands and their use to Provide Bioremediation of Farm Effluents in Northern Ireland: A review of current literature. Department of Agriculture and Rural Development. Agricultural Research Institute of Northern Ireland, Hillsborough.

[13] Pucci, B., Conte, G., Martinuzzi, N., Giovannelli, L., Masi, F., 2000. Design and performance of a horizontal flow constructed wetland for treatment of dairy and agricultural wastewater in the "Chianti" countryside. In Atti del 7 congresso internazionale del gruppo specialistico IWA sull'utilizzo di macrofite per il controllo dell'inquinamento delle acque. pp. 1433-1436.

[14] Jing, S., Lin, Y., Lee, D., Wang, T., 2001. Nutrient Removal from Polluted River Water by Using Constructed Wetlands. Bioresource Technology. 76, 131-135.

[15] Li, L., Li, Y., Biswas, D. K., Nian, Y., Jiang, G., 2008. Potential of constructed wetlands in treating the eutrophic water: evidence from Taihu Lake of China. Bioresource Technology. 99(6), 1656-1663.

[16] Vymazal, J., 2011. Constructed wetlands for wastewater treatment: five decades of experience. Environmental Science and Technology. 45(1), 61-69.

[17] Vymazal, J., 2010. Constructed wetlands for wastewater treatment. Water. 2(3), 530-549.

[18] Xu, J., Zhang, J., Xie, H., Li, C., Bao, N., Zhang, C., Shi, Q., 2010. Physiological responses of Phragmites australis to wastewater with different chemical oxygen demands. Ecological Engineering. 36(10), 1341-1347.

[19] Lehl, H.K., Ong, S.A., Ho, L.N., Wong, Y.S., Naemah Mohd Saad, F., Oon, Y.L., Oon, Y.S., Yong, C.Y., Thung, W.E., 2016. Multiple aerobic and anaerobic baffled constructed wetlands for simultaneous nitrogen and organic compounds removal. Desalination and Water Treatment. 57(60), 29160-29167.

[20] Phan, T.D., Dinh, N.T., 2017. Highly Efficient Treatment of Shrimp Farm Wastewater by Using the Horizontal Subsurface Flow (HSSF) Constructed Wetlands with Phragmites australis Plant. Asian Journal of Environment & Ecology. 4(3), 1-9.

[21] Manh, N.C., Minh, P.V., Hung, N.T.Q., Son, P.T., Ky, N.M., 2019. A study to assess the effectiveness of constructed wetland technology for polluted surface

 DOI: http://dx.doi.org/10.36956/njas.v4i1.455

water treatment. VNU Journal of Science: Earth and Environmental Sciences. 35(2), 11-22.

[22] Haslam, S.M., 2010. A Book of Reed: (Phragmites australis (Cav.) Trin. ex Steudel, FormerlyPhragmites communis Trin.). Forrest Text, Cardigan, GB, 254.

[23] Allirand, J.M., Gosse, G., 1995. An aboveground biomass production model for a common reed (Phragmites communis Trin.) stand. Biomass and Bioenergy. 9(6), 441-448.

[24] Ridderstolpe, P., 2004. Introduction to Greywater Management. Stochholm Environment Institute, Sweden, Report 2004-4.

[25] Deguenon, H.E.J., Hounkpe, M.P., Aina, J.A., Sohounhlore, D.C.K., 2013. Purification Performances of Common Reed beds Based on the Residence time: Case study of Benin. Journal of Applied Biosciences. 71, 5682-5691.

[26] Marzec, M., Jozwiakowski, K., Debska, A., Gizinska-Goma, G., Pytka-Woszczylo, A., Kowalazyk-Jusko, A., Listosz, A., 2018. The Efficiency and Reliability of Pollutant Removal in a Hybrid Constructed Wetland with Common reed, Manna grass and Virginia mallow. Water Journal. 10, 1-18.

[27] Kurniadie, D., Wijaya, D., Widayat, D., Umiyati, U., Iskandar, 2018. Constructed Wetland to Treat Tapioca Starch Wastewater in Indonesia. Asian Journal of Water, Environment and Pollution. 15(3), 10-113.

[28] Pescod, M.B., 1992. Wastewater treatment and use in agriculture. FAO Irrigation and Drainage. Pap. 4, Rome, Italy.

[29] Omami, E.N., 2005. Response of Amaranth to Salinity Stress. PhD Thesis, University of Pretoria, South Africa.

[30] Agarwal, S., Pandey, V., 2004. Atioxidant Enzyme Response to NaCl stress in Cassia angustifolia. Biologia Plantarum. 48(4), 555-560.

[31] Plaut, Z., Edelstein, M., Ben-Hur, M., 2013. Overcoming Salinity Barriers to Crop Production using Traditional Methods. Critical Reviews in Plant Sciences. 32(4), 250-291.

[32] Bilha, E., 2006. Biochemical Oxygen Demand reaction Kinetics and Mass Transfer in Horizontal Subsurface Flow Constructed Wetland. MSc Dissertation. University of Dar es Salaam.

[33] Seswoya, R., Zainal, M.Y., 2010. Subsurface-flow Constructed Wetland: Proposed design area for high strength effluent domestic wastewater.

[34] Nakwanit, S., Visoottiviseth, P., Khokiattiwong, S., Sangchoom, W., 2011. Management of arsenic accumulated waste from constructed wetland treatment of mountain tap-water. Journal of Hazardous Materials. 185, 1081-1085.

[35] Akinbile, C.O., Yusoff, M.S., Ahmad Zuki, A.Z. ,2012. Landfill Leachate Treatment using sub-surface flow constructed wetland by Cyperus haspan. Waste Manag. 32(7), 1387-1393.

[36] Tuheteru, F.D., Kusmana, C., Mansur, I., Iskandar, Tuheteru, E.J., 2016. Potential of Lonkida (Nauclea orientalis L.) for Phytoremediation of Acid Mined Drainage at PT. Bukit Asam Tbk. (Persero), Indonesia. Research Journal of Botany. 11(1-3), 9-17.

[37] Pongthornpruek, S., 2017. Swine Farm Wastewater Treatment by Constructed Wetland Planted with Vetiver Grass. Environment and Natural Resources Journal. 15(2), 13-20.

[38] Nguyen, P.M., Pham, H.T., Le, L.K.T., Vu, A.N., 2018. Capacity of wetland mesocosm planted with cyperus alternifolius in mining wastewater treatment. Asian Journal of Microbiology, Biotechnology and Environmental Sciences. 20(4), 1140-1146.

[39] Thathong, V., Tantamsapya, N., Yossapol, C., Liao, C.H., Wirojanagud, W., Padungthon, S., 2019. Role of Colocasia esculenta L. schott in arsenic removal by a pilot-scale constructed wetland filled with laterite soil. Heliyon 5, e01233.

[40] Prasetya, A., Prihutami, P., Warisaura, A.D., Fahrurrozi, M., Petrus, H.T.B.M., 2020. Characteristic of Hg removal using zeolite adsorption and Echinodorus palaefolius phytoremediation in subsurface flow constructed wetland (SSFCW) model. Journal of Environmental Chemical Engineering. 8(3), 103781.

[41] WHO, 1995. Manual for Recreational Water and Beach Quality Monitoring and Assessment. Draft. WHO regional office for Europe, European Center for Environment and Health.

DOI: http://dx.doi.org/10.36956/njas.v4i1.455

NASS Journal of Agricultural Sciences
http://ojs.nassg.org/index.php/NJAS

Infestation Rate and Abundance of Fruit Fly Species (Diptera, Tephritidae) on *Solanum aethiopicum, Solanum lycopersicum,* and *Capsicum* spp in Eastern of the Democratic Republic of Congo

Jean Augustin Rubabura Kituta[1*] Jean Berkmans Muhigwa Bahananga[2]

1. Agricultural Entomology laboratory, Entomology Section, Research Centre in Natural Sciences (CRSN-Lwiro), Bukavu, Congo
2. Department of Biology, State University of Bukavu (UOB-Bukavu), Bukavu, Congo

ARTICLE INFO

Article history
Received: 20 November 2021
Accepted: 14 December 2021
Published Online: 24 December 2021

Keywords:
Infestation rate
Incubation
Abundance
Tephritidae
Pests

ABSTRACT

This study assessing the infestation rate of fruit fly species on *Solanum aethiopicum, Solanum lycopersicum,* and *Capsicum* spp, using incubation method, was conducted in Agricultural entomology laboratory of Research Centre in Natural Sciences (CRSN) Lwiro, at Kabare in The South Kivu Province in eastern part of the Democratic Republic of Congo. Five species of Tephritidae flies observed, i.e. *Bactrocera dorsalis, B. latifrons, Dacus bivitatus, Ceratitis capitata,* and *Zeugodacus Cucurbitae.* The highest infestation rate was observed on *B. dorsalis* and following *C. capitata* in those solanaceous chilli pepper (*C. frutescens*), eggplant (*S. aethiopicum*) and tomato (*S. lycopersicum*) than Z. *cucurbitae, B. latifrons and D. bivittatus*. However, the localities Kamakombe, Buhandahanda, Lwiro, Bishibiru have predominant in the majority of hosts in chilli pepper, eggplant and tomato.

1. Introduction

Fruit flies (Diptera,Tephritidae) are listed among the most important pests of many fruits in the world. Representatives of the tribe Dacini comprise several economic pests, especially in the genera *Ceratitis* MacLeay, *Dacus* Fabricicus and *Bactrocera* Macquart [1]. The latter is a large genus, including more than 500 species with main distribution in Asia and Oceania. However, in Africa only a few indigenous species are known, none of them of great economic importance, except for the olive fruit fly [*Bactrocera oleae* (Gmelin)], which is a notorious pest of cultivated olives in the Mediterranean region. However, several Asian *Bactrocera* species have been introduced to Africa [2]. In Virgilio *et al.* (2011) [3] study, the McPhail traps baited with four different attractants yielded 819 tephritid specimens of 29 species from seven genera (Bactrocera, Carpophthoromyia, Ceratitis, Dacus, Celidodacus, Perilampsis, Trirhithrum). The three most abundant species sampled (*Dacus bivittatus, D. punctatifrons, Bactrocera invadens*) showed significant variations in abundance across locations and sites and accounted for 98.29% of the overall dissimilarity between habitats. He reported the abundant presence of

**Corresponding Author:*
Jean Augustin Rubabura Kituta,
Agricultural Entomology laboratory, Entomology Section, Research Centre in Natural Sciences (CRSN-Lwiro), Bukavu, Congo;
Email: dodorubabura@gmail.com

 DOI: http://dx.doi.org/10.36956/njas.v4i1.457

Dacus bivittatus, *Bactrocera invadens* (currently referred to as *Bactrocera dorsalis*) and *Dacus punctatifrons* and to a lesser extent of *Carpophthoromyia tessmanni*, *Ceratitis cosyra*, *Ceratitis* (*Pardalaspis*) sp., *Ceratitis* (*Pterandrus*) sp., *Ceratitis serrata*, *Ceratitis striatella*, *Dacus ciliatus*, *Dacus gypsoides*, *Dacus radmirus*, *Dacus setilatens*, *Trirhithrum nigerrimum*, *Trirhithrum obscurum* and the presence of other fruit flies Tephritidae; *Dacus humeralis, Dacus fumosus, Dacus Langi*, on the tropical forest and the rural villages of the Congo River basin (Congo, Lomami, Aruwimi, Itimbiri) on Oriental province of the Democratic Republic of Congo. Rubabura *et al.* (2015) [4] captured in their study on Kabare territory of the South Kivu province in the DR Congo an abundant quantity of *Ceratitis fasciventris*, afterwards *C. cosyra, Ceratitis anonae* and the presence of *Ceratitis capitata, Ceratitis rosa* and *Ceratitis punctata*. Again Rubabura *et al*. (2019) [5] reported an important abundance of fruit flies *B. dorsalis* and *Ceratitis fasciventris* and also, the less abundance of *C. cosyra, C. anonae* and *D. bivittatus* as well as the presence of *Dacus punctatifrons, Dacus eminus, C. capitata, C. rosa, Perilampsis curta, C. punctata, Zeugodacus cucurbitae, Bactrocera mesomelas, Dacus hargreavesi, Dacus siliqualactis, Dacus hamatus* and *Carpophthoromyia vittata* in South Kivu, the Albertine Rift zone part of the Democratic Republic of Congo. Up till now most studies focusing on fruit flies in the region did not include solanaceous crops. The three solanaceous species eggplant (*Solanum aethiopicum*), tomato (*Solanum lycopersicum = Lycopersicon Lycopersicon = Lycopersicon esculentum*), pepper and capsicum (*Capsicum* spp) are the major commercial crops in South Kivu, at the eastern part of the Democratic Republic of Congo. Those solanaceous species are attacked by more insect pest fruit flies Tephritidae and of other families (Aleyrodidae, Aphididae, Gelechiidae, Zygaenidae, Thripidae, Tetranychidae, Coccidae, etc). According to Mziray et al. (2010) [6], despite having a narrow host range, *B. latifrons* is a pest of quarantine importance and has the potential to permanently establish itself and compete and/or coexist with other native and previously introduced tephritid species. Because of this, elements of its population biology and demography [7-10] and dispersal and host preference [11] have been studied extensively in Hawaii for more than two decades. Thirty years ago, control measures in this region through the use of parasitoids [12] and twenty eight years ago, fruit fly bait [13] were presented, and thirty and over years, a specific lure was developed for its detection [14,15]. Nevertheless, *B. latifrons* has much less reproductive potential than the other Dacinae pests and is considered less competitive than *B. dorsalis, Z. cucurbitae* and *C. capitata* [7,16]. By referring to the increase in the cultivation of Solanaceae and the importation of this agricultural production (fresh vegetables and fruits) from the various border countries (Rwanda, Burundi and Tanzania) to South Kivu. Also, due to the low capacity for phytosanitary surveillance at the borders, South Kivu has suffered from the various invasions of harmful species over the last decade. These solanaceous can constitute a vast reservoir of superfluous and increase the rate of introduction of fruit flies in the province of South Kivu in the east of the Democratic Republic of the Congo. Again, no detailed study on presence and abundance of fruit fly species on solanaceous species (*S. aethiopicum, S. lycopersicum, Capsicum* spp) was conducted in Kabare altitude zone on South Kivu. The aim of our study was to know the species of Tephritidae flies, their infestation rate and to determine the abundance, adults of emerged flies by locality and by Solanaceae (*S. aethiopicum, S. lycopersicum, Capsicum* spp) present in the Bugorhe area in Kabare altitude zone on South Kivu, Eastern of the Democratic Republic of Congo.

2. Materials and Methods

2.1 Site and Location of Experiment

The particular study was conducted in Agricultural Entomology laboratory of the Research Centre in Natural Sciences (CRSN/Lwiro) during 2020 to 2021. It was carried out in Bugorhe area, which is located at the Kabare territory (Latitude: 2° 30′ and 2° 50′ S, Longitude: 28° 45′ and 28° 55′ E, South-Western of the Kivu Lake,Altitude: 1737 m) at the South Kivu province, eastern part of DR Congo. Simultaneously incubation of solanaceous carried out.

2.2 Data Collection

A pre-survey was carried out during the period from June, July until August 2020 in different localities of the Bugorhe area to inquire about information on the species of fruit and vegetables of cultivated Solanaceae market gardeners. Once the latter are known, 12 ripe fruits of these species *S. aethiopicum*, *S. lycopersicum*, *Capsicum* spp damaged or infested are picked 4 times in each of the localities during the study period in 2020 and 2021 and then the samples of these fruits are sent to the Agricultural Entomology laboratory of the Research Centre in Natural Sciences, CRSN-Lwiro for incubation. Collection depended on the availability of these Solanaceous fruits.

2.3 Incubation of Solanaceous Fruits

The frequency of sampling is invariable, but depends

DOI: http://dx.doi.org/10.36956/njas.v4i1.457

on the time of year. An incubation study was carried out over a two-months period from 10 February to 10 March 2020 and 2021 on *S. aethiopicum, Capsicum* spp collected in the field at Lwiro, Ciranga, Kamakombe, Kashenyi, Bishibiru, Kamakombe, Cegera and Buhandahanda localities, Kabare territory. For each fruit species, 12 fruits were sampled and incubated at periods of up to 4 or 5 weeks, depending on the stage of infestation of the fruits. Convenience sampling was used to select the fruits collected. It is a non-probability sampling plan where the sampling units are selected on purpose. The basis of selection was the presence of visual fruit fly puncture marks on the surface of the fruit. The infested fruits collected are placed in incubation units and provided with labels, following the method described by Ekesi and Billah (2007) [17]. The incubation units consist of two plastic tubs of different diameters, depending on the size of the fruits. All fruits collected were washed, weighed, placed and incubated (4 fruits per box individually). The bins are respectively 30 cm and 20 cm in diameter. The trays are superimposed, a layer of fine sand 2 to 3 cm thick at the bottom of the large tray, on which is placed the second small tray containing the infested fruit (s) to be incubated. The trays are then covered with a fine cloth or muslin cloth, to ensure good ventilation of the medium and prevent secondary infestations during incubation. Then, the boxes with the fruits are placed in the laboratory to allow the flies to form pupae. The pupae are removed from the sand by sieving from the first 10 days of incubation. The sand is sieved at intervals of 3 to 4 days. The pupae are counted and placed in Petri dishes and / or in a transparent box with a perforated lid, lined with toilet paper and kept in cages until adults emerge. The sieving is continued until the fruit has completely rotten. They are then dissected to collect any residual pupae or larvae. The methods of breeding fruit flies are described by Ekesi *et al.* (2007) [18] were used. The pupae are separated and then counted. After emergence of adult flies, Tephritidae are placed in tubes filled with ≥ 90% ethanol for storage. Before, the fruit flies emerging in each species of fruit collected are separated by sex, counted according to the 4 lots and the locality of origin and then, determine. The total number of different species of flies also emerging in each species of fruit collected is separated by sex, counted according to the 4 lots and the locality of origin.

2.4 Identification of Tephritidae

Several types of determination keys are used: the recent systematic review of tephritids including that of White and Elson-Harris (1994) [1], CABI (2005) [19], White (2006) [20], De Meyer *et al.* (2008) [21].

2.5 Statistical Analysis

The fruit collection followed the procedures used by Copeland *et al*. (2002) [22]. Next, the fruit fly infestation rate (expressed as the number of emerging adults per unit fruit weight) was calculated:

• The infestation rate (IR) measures the extent of Tephritidae host species emerged in fruits and is expressed as the number of pupae per unit of weight [23]. This parameter was determined by site according to the solanaceous, host species but also for the entire study area, considering these different levels of observation. The formula below was used for the calculation of infestation rate of host species:

$$IR = \frac{Number\ of\ host\ species\ \ emerged\ from\ the\ infested\ fruits\ of\ the\ sample}{Average\ weight\ of\ infested\ fruits\ in\ the\ sample\ in\ Kg.}$$

• The relative abundance (RA) and frequency (F) of fruit fly species incubated were calculated by the following formulae:

$$RA\ = \frac{Total\ number\ of\ fruit\ flies\ \ emerged\ of\ one\ species}{Total\ number\ of\ species\ emerged}$$

$$F = \frac{Total\ number\ of\ fruit\ flies\ emerged\ of\ \ one\ specie}{Total\ number\ of\ \ all\ species\ emerged} x\ 100$$

Principal coordinate's analysis of host fruit flies Infestation Rate was done by using the software PAleontological Statistics (PAST) Version 4.07. The rarefaction is a technique to assess species richness from the results of sampling. In fact, the Principal coordinate's analysis, also known as classical scaling, is a metric multidimensional scaling method based on projection, which uses spectral decomposition to approximate a matrix of distances/dissimilarities by the distances between a set of points in few dimensions. The points may be used in visualizations.

The temporal abundance of tephritidae flies is determined from samples of fruits *S. aethiopicum, S. lycopersicum, Capsicum* spp from the geographical position (longitude and latitude) of these 8 localities of the Bugorhe area by using Data Location and Inverse Distance to a Power. The methods mentioned above explains the statistics for Data Locations are concerned with the location of the data points: The location of data points is often useful when determining the density or the distance from each other and the values calculated in the statistics are in the same units as the original data set. So, the data metrics are calculated based on the XY data points. The DTMs are derived by using different interpolation methods. Indeed, the applied interpolation methods can be changed depending on the structure of the surface and the number of control points [24]. In this study, a different interpolation method is interpreted to

 DOI: http://dx.doi.org/10.36956/njas.v4i1.457

define a surface. Measured points are transferred to Surfer 17.1 software and the volume of the object is calculated by using the previously mentioned interpolation methods. So, the better the surface is described, the closer the amount of volume is to the real value. According the results closest to the real value of the volume is obtained from the following methods: inverse distance to a power (95.00%). The most suitable contour map of the object is obtained from the triangulation with linear interpolation and inverse distance to a power method. The most suitable 3D model of the object is obtained from triangulation with inverse distance to a power method.

Software R [25] was used to analyze Linear Model Regression of flies and making histogram and boxplot of fruit flies observed during incubation of Solanaceous. Mean and standard deviation were calculated too.

3. Results

3.1. Tephritidae Fruit Fly Species Observed

The Figure 1 presented the relative abundance of the host fruit flies between the localities. In fact, the fruit flies *B. dorsalis* was more abundant in Bishibiru locality (0.074) and Nyamakana locality (0.078) than in Buhandahanda locality (0.124), Ciranga-Kankule locality (0.265) and Kashenyi locality (0.399) in the green histogram. Also, *Z. cucurbitae* was more abundant in abundant in Buhandahanda locality (0.001) and Bishibiru, Kamakombe and Lwiro localities (0.002) than in Cegera and Kashenyi localities (0.004), and Ciranga-Kankule locality (0.005) in the red histogram behind. However, the fruit flies *D. bivittatus* was more abundant in Cegera, Bishibiru, Kashenyi and Lwiro localities (0.001) than in Ciranga-Kankule locality (0.004) in the yellow histogram. So, the fruit flies *B. latifrons* was more abundant in Bishibiru, Cegera, Kamakombe, Kashenyi and Nyamakana localities (0.001) than in Ciranga-Kankule and Buhandahanda localities (0.004) and Lwiro locality (0.007) in the blue histogram. Then, the fruit flies *C. capitata* was more abundant in Bishibiru locality (0.001) than in Lwiro locality (0.004) and Nyamakana locality (0.005) in the red histogram below.

3.2 Infestation Rate of Fruit Flies' Species

In view of principal coordinates (PCoA) in the Figure 2 and 3, the highest infestation rate was observed on *B. dorsalis* and following *C. capitata* in those solanaceous fruits chosen in the study compare to host *Z. cucurbitae*, *B. latifrons* and *D. bivittatus* (Figure 2). The solanaceous fruits have more infestation rate of host in Kamakombe, Buhandahanda, Lwiro, Bishibiru localities than in Kashenyi, Ciranga-Kankule and Nyamakana localities (Figure 3).

3.3 Temporal Abundance

The Figure 4 is a use of the count data metrics can be represented in the map below. The grid represents the number of fruit flies observed during the incubation in study area. Then, this map can then be used to represent a link between the number of fruit flies (*B. dorsalis, B. latifrons, D. bivittatus, C. capitata, Z. cucurbitae*) and the location. In those maps, temporal abundance is in accordance with zoning of the color *i.e.* the red color shows the huge temporal abundance of species in those maps following with the yellow color which has a great temporal abundance of species compare to the green and blue colors. After yellow color is coming the green color and, the later blue color.

Additionally, the Figure 5 of the inverse distances to a power shows the visually maps of irregularly spaced *B. dorslis*, *B. latifrons, C. capitata, D. bivittatus* and *Z. cucurbitae* in surface of this area. Additionally, *B. dorslis*, *B. latifrons, C. capitata, D. bivittatus* and *Z. cucurbitae* set has a stationary variance but also a non-stationary mean value within the search radius. According below map, the fruit flies are present in the area study. The top shows the great temporal abundance and the emptiness explains the minor temporal abundance in those inverse distances to power of species.

3.4 Fruit Fly Species Recorded on Solanaceous

Several fruit flies were observed such as *B. dorsalis, B. latifron, Z. cucurbitae, D. bivittatus* and *C. capitata.* The average at eggplant was of 69 larvae per kg of fruit ± 41.78 for *B. dorsalis,* of *2* larvae per kg of fruit ± 0.97 for *Z. cucurbitae*, of 2 larvae per kg of fruit ± 0.89 for *D. bivittatus* and of 1 larva per kg of fruit ± 1.13 for *B. latifrons.* According chili pepper, the average was of 44 larvae per Kg of fruit ± 33.70 for *B. dorsalis* and of 1 larva per kg of fruit ± 0.58 for *B. latifrons*. Additionally, the average of *B. dorsalis* on tomato was of 57 larvae per kg of fruit ± 39.59 and of 3 larvae per kg of fruit ± 1.53 *C. capitata* on pepper. The boxplot and the linear model regression show tendency of fruit flies observed during incubation of Solanaceous fruits (Figures 6 and 7).

DOI: http://dx.doi.org/10.36956/njas.v4i1.457

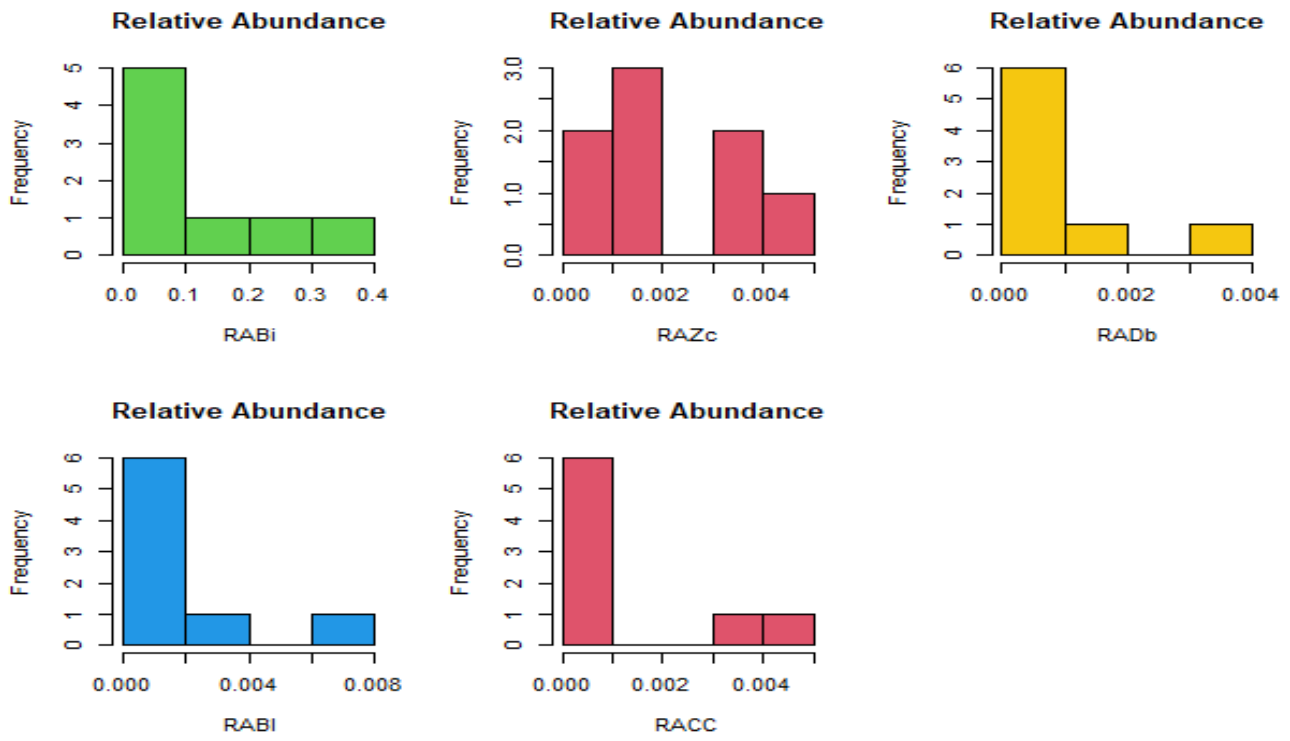


Figure 1. Relative abundance of host between the localities

RA: Relative abundance, Bi: *Bactrocera dorsalis* Hendel; Bl: *Bactrocera latifrons* (Hendel); Zc: *Zeugodacus cucurbitae* (Coquillett); Cc: *Ceratitis capitata* (Wiedemann); Db: *Dacus bivittatus* (Bigot).

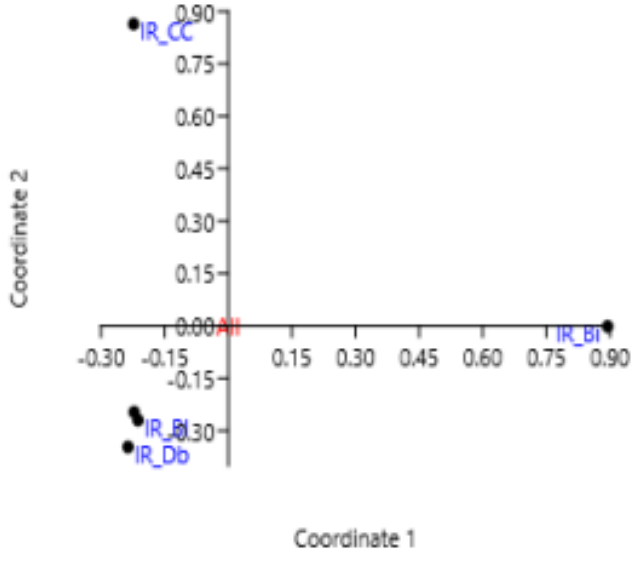


Figure 2. Host Infestation rate per species

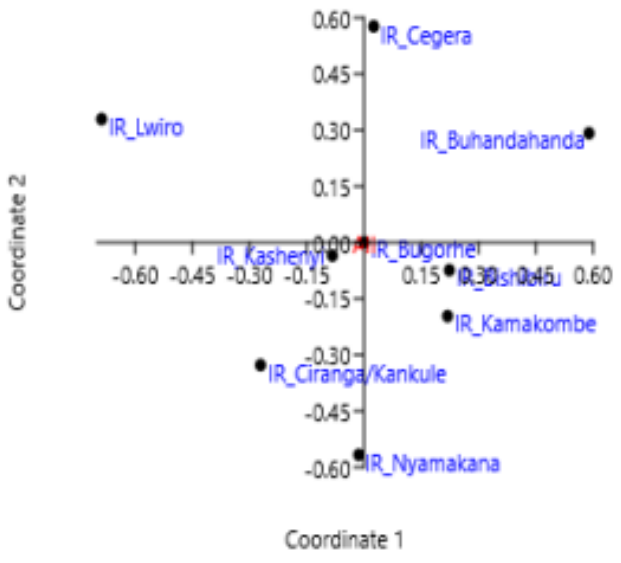
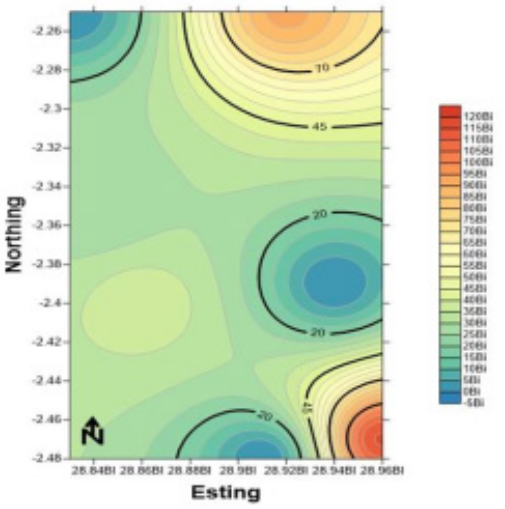
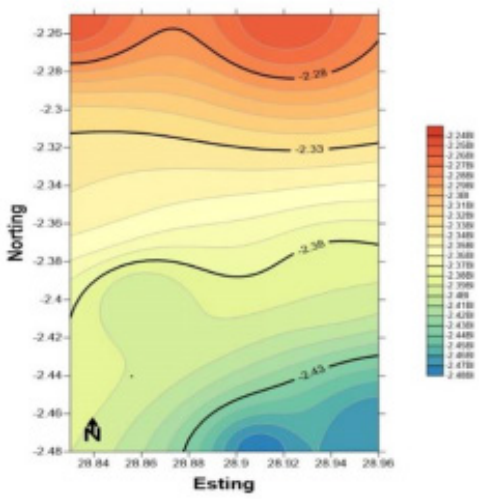


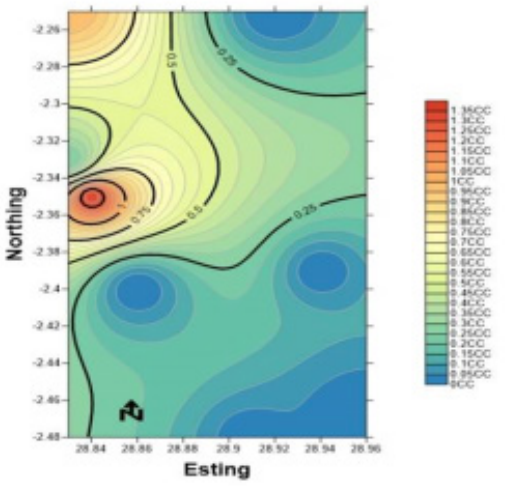
Figure 3. Host Infestation rate per localities



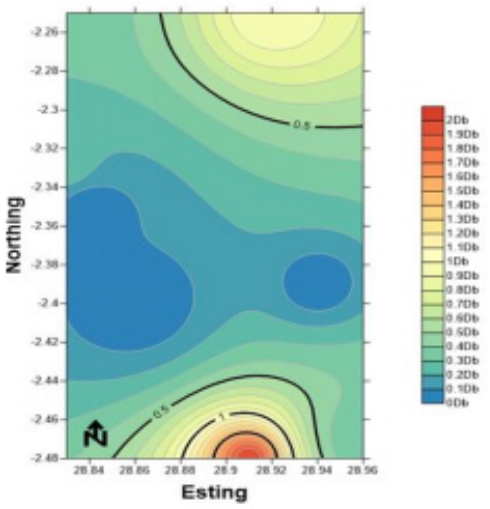
***B. dorasalis* map**



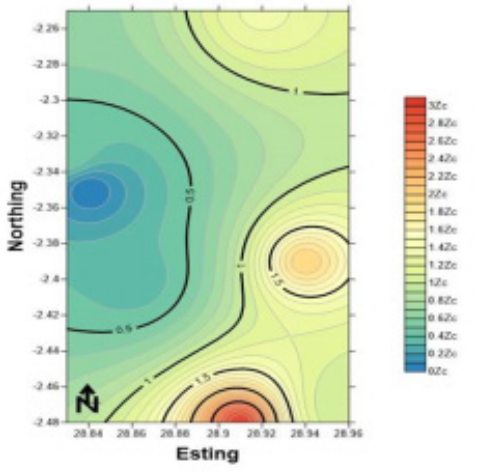
***B. latifrons* map**



***C. capitata* map**



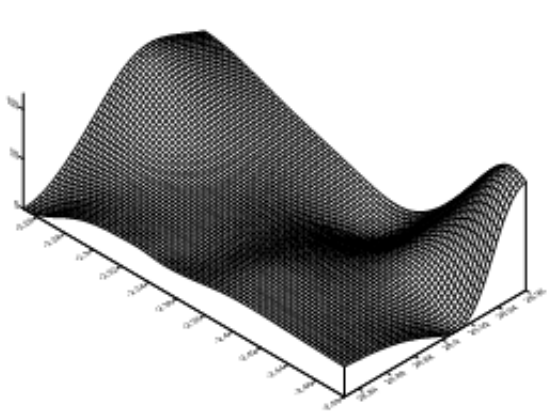
***D. bivittatus* map**



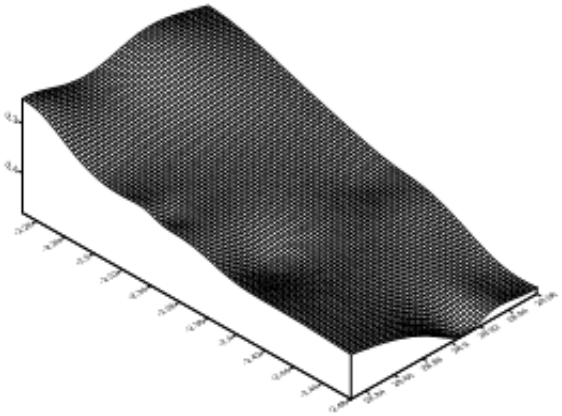
***Z. cucurbitae* map**

Figure 4. Data Locations of different fruit flies in area of study

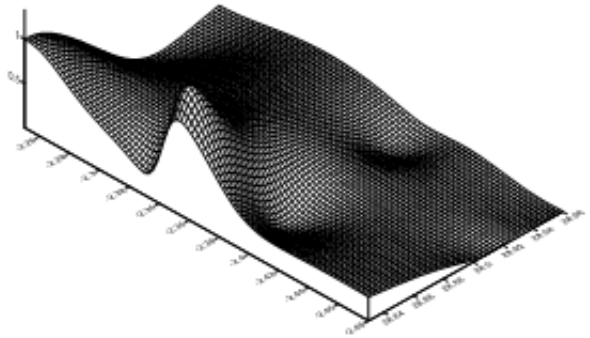
DOI: http://dx.doi.org/10.36956/njas.v4i1.457



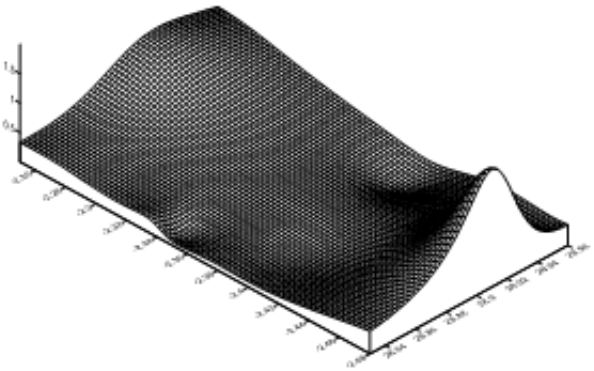
Inverse distance to a power of *B. dorsalis*



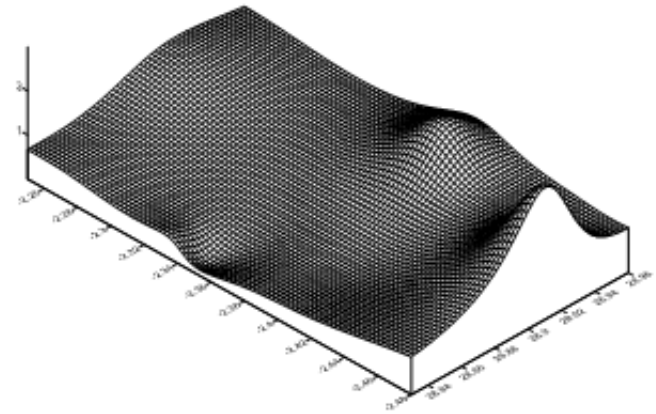
Inverse distance to a power of *B. latifrons*



Inverse distance to a power of *C. capitata*



Inverse distance to a power of *D. bivittatus*



Inverse distance to a power of *Z. cucurbitae*

Figure 5. Inverse distance to a power of different fruit flies in area of study

 DOI: http://dx.doi.org/10.36956/njas.v4i1.457

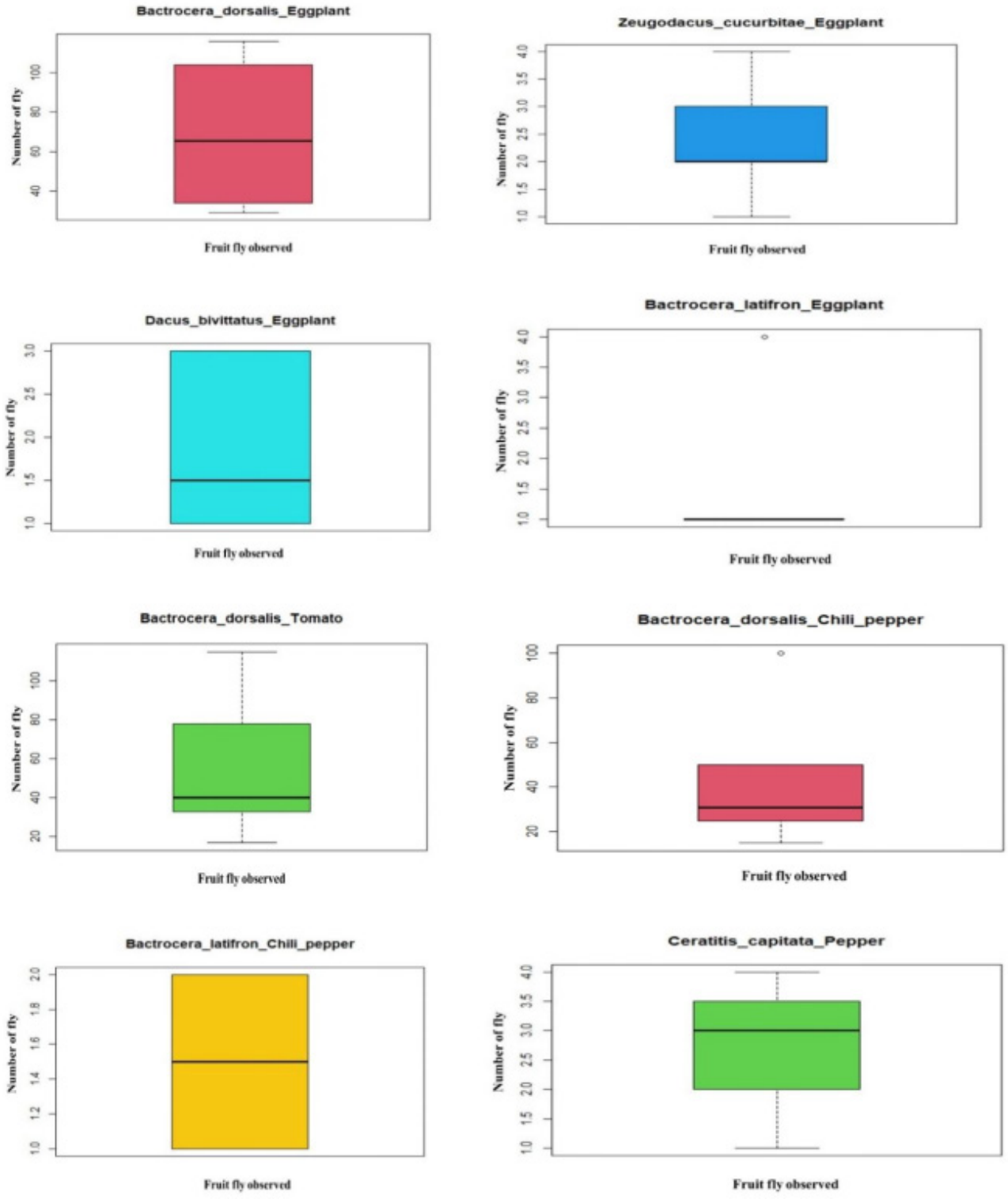


Figure 6. Boxplot of fruit flies observed during incubation of Solanaceous

DOI: http://dx.doi.org/10.36956/njas.v4i1.457

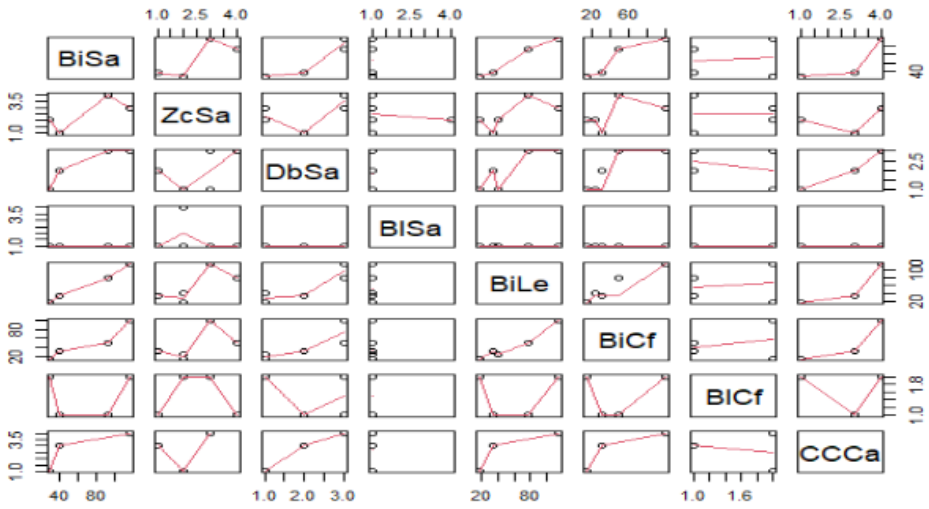


Figure 7. Linear model regression of flies observed

Bi: Bactrocera dorsalis, Bl: Bactrocera latifrons, Db: Dacus bivittatus, CC: Ceratitis capitata, Zc: Zeugodacus cucurbitae, Sa: Solanum aethiopicum, Le: L. esculentum, Cf: Capsicum frutescens, Ca: Capsicum annuum

4. Discussion

The highest relative abundance of *B. dorsalis* was in Bishibiru locality (0.074) than in Nyamakana locality (0.078), Buhandahanda locality (0.124), Ciranga-Kankule locality (0.265) and Kashenyi locality (0.399), Kamakombe and Lwiro localities (0.002) than in Cegera and Kashenyi localities (0.004), and Ciranga-Kankule locality (0.005). However, the predominant of *D. bivittatus* was more in Cegera, Bishibiru, Kashenyi and Lwiro localities (0.001) than in Ciranga-Kankule locality (0.004). So, the majority of hosts' *B. latifrons* was in Bishibiru, Cegera, Kamakombe, Kashenyi and Nyamakana localities (0.001) than in Ciranga-Kankule and Buhandahanda localities (0.004) and Lwiro locality (0.007). Then, the fruit flies *C. capitata* was more abundant in Bishibiru locality (0.001) than in Lwiro locality (0.004) and Nyamakana locality (0.005). Most fruit species can be grown on the highland due to the subtropical climate [26]. Altitude by itself does not determine fruit fly distribution but associated with other factors such as weather and host plants availability play an important role (Mwatawala et al., 2006; Geurts et al., 2012) [27,28].

The highest infestation rate was observed on *B. dorsalis* and following *C. capitata* in those solanaceous. This result goes in the same way of Mwatawala et al. [29], *B. dorsalis* was the dominant species in incidence expressed as the ratio of infested to total number samples collected, as well as infestation rate, expressed as number of flies emerging per unit weight. Infestation by native pests, such as *C. capitata* and *C. cosyra*, was minor compared to *B. invadens*. Indeed, several authors Vargas and Nishida (1985b) [30], White and Elson-Harris (1994) [1] and Mziray et al. (2010) [6] shows that *B. dorsalis* and *Z. cucurbitae* are the highly aggressive invasive species and also, *C. capitata, D. ciliatus, D. punctatifrons* and *D. bivittatus* are the major native pest pests on the areas of ecological interest. So, the invasive oriental fruit fly, *B. dorsalis* was recorded in Africa mainland since 2003 [31]. However, soon after its discovery in Kenya, *B. dorsalis* spread throughout Africa [32,33]. So, in many countries *C. capitata* species is often considered as highly polyphagous with almost 400 host plants known worldwide [34-37]. It is an other exotic polyphagous Tephritidae of major economic impacts are, most of the records date back from the 1950s such as the mango fruit fly the Mediterranean fruit fly *Ceratitis capitata* Wiedemann [38,39].

The localities Kamakombe, Buhandahanda, Lwiro, Bishibiru have predominant in the majority of hosts in solanaceous fruits than Kashenyi, Ciranga-Kankule and Nyamakana localities this may be explained by the use of more vegetable activities in those areas [40] and the high dependence on pesticides by vegetable farmers is an indication that they are not aware of other pest management strategies that are effective, inexpensive and yet friendly to the environment. This improper use of pesticides by market gardeners may induce resistance of pest to pesticides in those areas [41].

Furthermore, a few adults of *B. dorsalis* emerged from *Capsicum annuum* specie in this study in east of DRC, where Chili pepper (*C. frutescens*), eggplant (*S. aethiopicum*) and tomato (*S. lycopersicum*) were highly preferred by *B. dorsalis*. This result goes in the same way

with the result of Badii *et al.* (2015) [42]. According to White and Elson-Harris (1992) [1], Sub-Saharan Africa is a reservoir of 915 fruit fly species from 148 genera, nearly, 299 of these species are considered as pests by feeding on fruits of economic importance. Three fruit fly species: *C. capitata*, *C. cosyra* and *C. rosa* Karsch are reported to attack *L. chinensis* in South Africa [43] and in La Réunion, *B. dorsalis* and *C. quilicii* De Meyer, Mwatawala & Virgilio were also recorded as a pest on this plant [44]. Commercial species of pepper and chilies are known to host *C. cosyra* and *B. dorsalis* in west and central African countries [42, 44]; *C. capitata*, *N. cyanescens* and *B. dorsalis* in some of the islands of the Indian Ocean [45].

Those fruit flies *B. dorsalis, B. latifrons, D. bivitatus, C. capitata, Z. cucurbitae* were located in study area. This result rejoined the result of Rubabura *et al*. (2019; 2021) [5,46], Ndayizeye et al. (2019) [47] and Ndayizeye and Kataraka (2021) [48]. Several fruit flies were observed such as *B. dorsalis, B. latifrons, Z. cucurbitae, D. bivittatus* and *C. capitata*. The average at eggplant was of 69 ± 41.78 for *B. dorsalis*, of 2 ± 0.97 for *Z. cucurbitae*, of 2 ± 0.89 for *D. bivittatus* and of 1 ± 1.13 for *B. latifrons*. According chili pepper, the average was of 44 ± 33.70 for *B. dorsalis* and of 1 ± 0.58 for *B. latifrons*. Additionally, the average of *B. dorsalis* on tomato was of 57 ± 39.59 and of 3 ± 1.53 *C. capitata* on pepper. The result goes in the same way of the result of Rubabura *et al.* (2021) [46].

5. Conclusions

It was concluded the five species of Tephritidae flies observed such as *B. dorsalis, B. latifrons, D. bivitatus, C. capitata, Z. cucurbitae* and the highest infestation rate was observed on *B. dorsalis* and following *C. capitata* in those solanaceous chilli pepper (*C. frutescens*), eggplant (*S. aethiopicum*) and tomato (*S. lycopersicum*) than *Z. cucurbitae, B. latifrons* and *D. bivittatus*. However, the localities Kamakombe, Buhandahanda, Lwiro, Bishibiru have predominant in the majority of hosts in chilli pepper, eggplant and tomato.

Acknowledgement

The authors are thank-full to Marc De Meyer of Invertebrates Section at the Royal Museum for Central Africa for the many tips, for the ideas, proofreading and correction of this article as well as for the unfailing emotional support and the Bugorhe Agriculture Farm and agents of agricultural entomology laboratory of the Research Centre in Natural Sciences (CRSN) Lwiro, for providing facilities and cooperation for the conduction of this experiment.

References

[1] White, I.M. and Elson-Harris, M.M., 1994. Fruit flies of economic significance: their identification and bionomics [reprint with addendum]. *CAB International*, Wallingford.

[2] White, IM., 2006. Taxonomy of the Dacina (Diptera: Tephritidae) of Africa and the Middle East. *Afr. Entomol.Mem.* 2, 1-156.

[3] Rubabura, K.JA., Munyuli, B.M.T., Bisimwa, B.E. and Kazi, K.S., 2015. Invasive fruit fly, Ceratitis species (Diptera: Tephritidae), pests in South Kivu region, eastern of Democratic Republic of Congo. International *Journal of Innovation and Scientific Research*. 16(2):403-408.

[4] Virgilio, M., Backeljau, T., Emeleme, R., Juakali, J.L. and De Meyer, M., 2011. A quantitative comparison of frugivorous tephritids (Diptera: Tephritidae) in tropical forests and rural areas of the Democratic Republic of Congo. *Bull Entomol Res*. 101(5):591-597.

[5] Rubabura, K.JA., Chihire, B.P., Bisimwa, B.E., 2019. Diversity and abundance of fruit flies (family: Tephritidae) in the Albertine rift zone, Democratic Republic of the Congo, and preliminary prospects for biological control. *Adv Plants Agric Res.* 9(1):41-48. DOI: https://doi.org/10.15406/apar.2019.09.00408.

[6] Mziray, H.A., Makundi, R.H., Mwatawala, M., Maerere, A.A and De Meyer, M., 2010. Host Use of *Bactrocera latifrons,* a New Invasive Tephritid Species in Tanzania, Ecology and behavior. *J. Econ. Entomol*. 103(1): 70-76.
DOI: https://doi.org/10.1603/EC09212.

[7] Vargas, R.I. and Nishida, T., 1985a. Life history and demographic parameters of *Dacus latifrons* (Diptera: Tephritidae). *J. Econ. Entomol.* 78: 1242 1244.

[8] Vargas, R.I., Walsh, W.A., Armstrong, J.W., Jang, E.B. and Kanehisa, D., 1996. Survival and development of immature stages of four Hawaiian fruit flies (Diptera: Tephritidae) reared at five different temperatures. *Ann. Entomol. Soc. Am.* 89: 64 -69.

[9] Vargas, R.I., Walsh, W.A., Kanehisa, D., Jang, E.B. and Armstrong, J.W., 1997. Demography of four Hawaiian fruit flies (Diptera: Tephritidae) reared at five constant temperatures. *Ann. Entomol. Soc. Am.* 90: 162-168.

[10] McQuate, G.T., Bokonon-Ganta, A.H. and Peck, S.L., 2007. Population biology and prospects for suppression of the solanaceous fruit fly, *Bactrocera latifrons* (Diptera: Tephritidae). *Proc. Hawaiian Entomol. Soc.* 39: 111-115.

[11] Peck, S.L. and McQuate, G.T., 2004. Ecological as-

  DOI: http://dx.doi.org/10.36956/njas.v4i1.457

pects of *Bactrocera latifrons* (Diptera: Tephritidae) on Maui, Hawaii: movement and host preference. *Environ. Entomol.* 33: 1722-1731.

[12] Bokonon-Ganta, A.H., McQuate, G.T. and Messing, R.H., 2007. Natural establishment of a parasitoid complex on *Bactrocera latifrons* (Diptera: Tephritidae) in Hawaii. *Biol. Control* 42: 365-373.

[13] McQuate, G.T., 2009. Effectiveness of GF-120 fruit fly bait as a suppression tool for *Bactrocera latifrons* (Diptera: Tephritidae). *J. Appl. Entomol.* 133: 444-448.

[14] McQuate,G.T. and Peck, S.L., 2001. Enhancement of attraction of alpha-ionol to male *Bactrocera latifrons* (Diptera: Tephritidae) by addition of a synergist, cade oil. *J. Econ. Entomol.* 94: 39-46.

[15] McQuate, G. T., Keum, Y.-S., Sylva, C. D., Li, Q. X. and Jang, E. B., 2004. Active ingredients in cade oil which synergize the attractiveness of α-ionol to male *Bactrocera latifrons* (Diptera: Tephritidae). *J. Econ. Entomol.* 97: 862-870.

[16] Yang P., 1992. Demographic investigations on selected dacine fruit flies in southern China and Hawaii. Ph. D. dissertation, University of California, Davis.

[17] Ekesi, S., De Meyer, M., Mohamed, S. A., Virgilio, M. and Borgemeister, C., 2016. Taxonomy, ecology and management of native and exotic fruit fly species in Africa. *Annual Review of Entomology*, Vol 61, 61, 219-238.

[18] Ekesi, S. and Billah, M.K., 2007. A field guide to the management of economically important tephritid fruit flies in Africa.*ICIPE Science Press*, Nairobi, Kenya.

[19] CABI., 2005. Crop Protection Compendium, Edition. Commonwealth Bureau of Agriculture International, Wallingford, UK.

[20] White, I.M., 2006. Taxonomy of the Dacina (Diptera: Tephritidae) of Africa and the Middle East. *Afr. Entomol. Mem.* 2, 1-156.

[21] De Meyer, M., Mohamed, S., White, I.M., 2014. Invasive Fruit Fly Pests in Africa. A diagnostic tool and information reference for the four Asian species of fruit fly (Diptera, Tephritidae) that have become accidentally established as pests in Africa. Http://www.africamuseum.be/fruitfly/AfroAsia.htm (website accessed on 1/12/2008).

[22] Copeland, R.S., Wharton, R.A., Luke, Q. and De Meyer, M., 2002. Indigenous hosts of Ceratitis capitata (Diptera: Tephritidae) in Kenya. *Ann. Entomol. Soc. Am*. 95, 672-694.

[23] Vayssières, JF, Sinzogan, A, Adandonon, A., 2009. Principales méthodes de lutte intégrée contre les mouches des fruits en Afrique de l'Ouest. Fiche Nº6. Projet Régional de Lutte Contre les Mouches des Fruits en Afrique de l'Ouest. UPR Production Fruitière, Montpellier, France; IITACIRAD. Cotonou - Bénin. p.4.

[24] Yilmaz, M.H., 2007. The effect of interpolation methods in surface definition: an experimental study. *Earth Surf. Process. Landforms*, 32, 1346-1361. DOI: https://doi.org/10.1002/esp.1473

[25] R Core Team, 2018. R: A Language and Environment for Statistical Computing.Vienna: R Foundation for Statistical Computing. https://www.R-project.org.

[26] Rasolofoarivao, H., Raveloson Ravaomanarivo, L.H., Delatte, H., 2021. Host plant ranges of fruit flies (Diptera: Tephritidae) in Madagascar. *Bulletin of Entomological Research* 1-12. DOI: https://doi.org/10.1017/S000748532100051.

[27] Mwatawala, M.W., De Meyer, M., Makundi RH and Maerere, A.P., 2006. Biodiversity of fruit flies (Diptera, Tephritidae) in orchards in different agro-ecological zones of the Morogoro region, Tanzania. *Fruits* 61, 321-332.

[28] Geurts, K., Mwatawala ,M., De Meyer, M. and Heckel, D., 2012. Indigenous and invasive fruit fly diversity along an altitudinal transect in Eastern Central Tanzania. *Journal of Insect Science* 12, 1536-2442.

[29] Mwatawala, M., De Meyer, M., Makundi R. and Maerere, A., 2009. Host range and distribution of fruit-infesting pestiferous fruit flies (Diptera, Tephritidae) in selected areas of Central Tanzania. *Bulletin of Entomological Research* , 99, 629-641.

[30] Vargas R. I., Nishida T., 1985b. Survey of *Dacus latifrons* (Diptera: Tephritidae). *J. Econ. Entomol*. 78: 1311-1314.

[31] Lux, S.A., Copeland, R.S., White, I.M., Manrakhan, A. and Billah, M.K., 2003. A new invasive fruit fly species from the *Bactrocera dorsalis* (Hendel) group detected in East Africa. International *Journal of Tropical Insect Science* 23, 355-361.

[32] De Meyer, M., 2000. Systematic revision of the subgenus Ceratitis MacLeay s.s.(Diptera, Tephritidae). *Zoological Journal of the Linnean Society* 128,439-467.

[33] De Meyer, M., Robertson, M.P., Mansell ,M.W., Ekesi, S., Tsuruta, K., Mwaiko, W.,Vayssieres, J-F. and Peterson, A.T., 2009. Ecological niche and potential geographic distribution of the invasive fruit fly *Bactrocera invadens* (Diptera,Tephritidae). *Bulletin of Entomological Research* 100, 35 -48.

[34] Liquido, N.J., Barr, P.G. and Cunningham, R.T., 1998. Medhost: An Encyclopedic Bibliography of the

Host Plants of the Mediterranean Fruit Fly, *Ceratitis capitata* (Wiedemann). USDA ARS.

[35] Liquido, N., McQuate, G. and Suiter, K., 2015. Medhost: An encyclopedic bibliography of the host plants of the Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann), version 3.0. USDA CPHST, Online Database.

[36] Copeland, R.S., Wharton, R.A., Luke, Q. and De Meyer, M., 2002. Indigenous hosts of *Ceratitis capitata* (Diptera: Tephritidae) in Kenya. Annals of the *Entomological Society of America* 95, 672-694.

[37] Moquet, L., Payet ,J., Glenac S and Delatte H, 2021. Niche shift of tephritid species after the Oriental fruit fly (*Bactrocera dorsalis*) invasion in La Réunion. Diversity and Distributions 27, 109-129.

[38] De Meyer, M., Quilici, S., Franck, A., Chadhouliati, A., Issimaila ,M., Youssoufa, M., Abdoul-Karime ,A-L., Barbet, A., Attié, M. and White, I., 2012. Records of frugivorous fruit flies (Diptera: Tephritidae: Dacini) from the Comoro archipelago. *African Invertebrates* 53, 69 -77.

[39] Dubois, J., 1965. La mouche des fruits malgache (*Ceratitis malgassa* Munro) et autres insectes des agrumes, pêchers et pruniers à Madagascar. *Fruits* 20,435-460.

[40] Report, 2021. Annually report of Agricultural Inspection of South Kivu, DRC.

[41] Van der Meijden, G., 1998. Pesticide application techniques in West-Africa. Food and Agriculture Organization of the United Nations FAO Regional Office for Africa Accra, Ghana and Agricultural Engineering Branch, Agricultural Support Systems Division, FAO, Rome, Italy.

[42] Badii, K., Billah, M., Afreh-Nuamah, K. and Obeng-Ofori, D., 2015. Species composition and host range of fruit-infesting flies (Diptera: Tephritidae) in northern Ghana. *International Journal of Tropical Insect Science,* 35, 137-151.

[43] Grové, T., Steyn, W.P. and De Beer, M.S., 2002. Fruit flies associated with litchi production in South Africa. Proceedings of 6th International Fruit Fly Symposium, Stellenbosch, South Africa, 313-316.

[44] Moquet, L., Payet, J., Glenac, S. and Delatte, H., 2021. Niche shift of tephritid species after the Oriental fruit fly (*Bactrocera dorsalis*) invasion in La Réunion. *Diversity and Distributions*, 27, 109-129.

[45] Franck, A. and Delatte, H., 2020. Plantes-hôtes des Mouches des fruits, Comores, Madagascar, Maurice, Mayotte, Réunion, Seychelles. *CIRAD* (Ed), pp. 160.

[46] Rubabura, K.JA. and Muhingwa, B.JB., 2021. Current status of the Solanum fruit fly *Bactrocera latifrons* (Hendel) in the eastern part of Democratic Republic of Congo.*Insect Environment*, Volume 24 (3)370-380.

[47] Ndayizeye, L., Nzigidahera ,B., Elamin Gesmallah, A., 2019. Detection of *Bactrocera latifrons* Hendel (Diptera: Tephritidae) on African eggplant in the different agro-ecological zones of Burundi. *International Journal of Tropical Insect Science*, 39(2): 1-6. DOI: https://doi.org/10.1007/s42690-019-00013.w.

[48] Ndayizeye, L., and Kataraka, C.B., 2021. First report of *Bactrocera latifrons* Hendel in the Democratic Republic of Congo. EPPO Bulletin. DOI: https://doi.org/10.1111/epp.12746.

DOI: http://dx.doi.org/10.36956/njas.v4i1.457

NASS Journal of Agricultural Sciences
http://ojs.nassg.org/index.php/NJAS

ARTICLE

Structural Traits, Structural Indices and Body Weight Prediction of Arsi Cows

Aman Gudeto[1*] Tesfaye Alemu Aredo[2] Tadele Mirkena[3] Sandip Banerjee[4]

1. Adami Tulu Agriculture Research Center, Adami Tulu Agricultural Research Center, Batu, Ethiopia
2. Oromia Agriculture Research Institute (IQQO), Addis Ababa, Ethiopia
3. Food and Agriculture Organization of United Nation (FAO), Addis Ababa, Ethiopia
4. College of Agriculture Science and Technology, India

ARTICLE INFO

Article history
Received: 26 July 2021
Accepted: 21 December 2021
Published Online: 4 January 2022

Keywords:
Cattle structural traits
Arsi cows
Structural indices
Body weight prediction

ABSTRACT

Structural measurements are indicators of animal performance, productivity and carcass characteristics. This study was conducted with the objectives of assessing structural measurements, developing body weight prediction and structural indices for cows of Arsi breed. The cows were purchased from highland and lowland agro-ecologies of Arsi and East Shoa zones of Oromia regional state, Ethiopia and kept in Adami Tulu Agricultural Research Center (ATARC) for the breed development purpose. Totally 222 cows were included in the structural traits measurement. Thirty four young heifers were also considered in the study. Twenty two structural traits were considered during observational survey. The structural index was calculated from the phenotypically correlated linear measurements. Structural traits were analyzed by T-test of SPSS version twenty four. The observed average values of height at wither, chest depth, heart girth, body length, pelvic width, cannon bone circumferences of the cows were 107, 55.62, 141.06, 117.82, 31.41 and 13.58cm, respectively. Heart girth (0.82), flank girth (0.73), hook circumferences (0.67), chest depth (0.65) and height at rump (0.64) were highly correlated (P< 0.01) to body weight of the cows. Regression analysis indicated that hearth girth had the highest coefficient of determination for body weight of the cows and heifers. Accordingly, the simple linear equations were developed to predict the body weight of cows and heifers. Body weight of Arsi cow (y) = -221.005 + 3.1(heart girth) and Body weight of Arsi heifer (y) = -188.452 + 2.75 (heart girth). Based on this, the measuring chart tape can be developed to estimate the body weight of Arsi cows and heifers at field condition where there is no access to weighing scales.

1. Background and Justification

Structural traits have been used for breed characterization and to describe changes in size and shape [1]. It provides a scientific basis to describe biological variations between breeds as well as within a breed and thus can serve as a basis for measuring the performance, productivity and carcass characteristics that vary due to genotypes, environment and nutrients [2].

Structural measurements serve as an alternative option for the assessment of body weight [3]. It is a best

**Corresponding Author:*
Aman Gudeto,
Adami Tulu Agriculture Research Center, Adami Tulu Agricultural Research Center, Batu, Ethiopia;
Email: amangude13@gmail.com

 DOI: http://dx.doi.org/10.36956/njas.v4i1.429

option where there is no access to weighing scales to predict animal body weight. Knowing body weight of animals is important for management decisions such as breeding, culling, feeding and determination of selling prices [4]. However, many farmers in developing countries grade their livestock using informal methods of quality estimation such as feeling the loin area or by visual estimation alone [5,6] because of lack of weighing scales and, if available, the weighing scales are mostly inaccurate due to lack of maintenance and calibration. Under such conditions, the livestock keepers are usually unable to receive a fair price for their livestock.

The structural indices are the combinations of several linear measurements which collate with type and function of particular breed. As indicated by Alderson [7], linear body measurements are used to calculate indices which show the structure and proportions of each animal. Structural indices are considered most useful because they have a neutral correlation with age. Consequently, assessment of structural indices is useful as a measure to select young animals for breeding purpose and predict mature rating. They provide a more realistic indicator for which a particular livestock breed was created and therefore provide a directional approach for further improvement of the same [5].

Arsi cattle are widely reared in Arsi, West Arsi, Bale, some parts of East Shoa and East Hararghe Zones of Oromia regional state, Ethiopia [8]. Adami Tulu Agriculture Research Center (ATARC) also handles Arsi cows at its farm for composite breed development. At ATARC, some morphometric measurements are being taken as baseline information for the breed improvement work being undertaken on this bred. Such information is necessary to see the differences attained after the breed improvement program. However, this breed has to be characterized phenotypically in detail using structural indices. Therefore, this study was designed to assess structural traits, develop body weight prediction and structural indices for Arsi cows.

2. Methodology

2.1 Study Area

Structural assessment was conducted at Adami Tulu Agricultural Research Center, which is located in mid rift valley at 167 km south from Addis Ababa, at an altitude of 1650 meter above sea level. The agro-ecological zone of the area is semi-arid and sub humid with acacia woodland vegetation type. The mean annual rain fall of the area is 760 mm and its mean minimum and maximum temperatures are 12.6 and 27 °C, respectably.

2.2 Sampled Population

ATARC keeps Arsi cows with the aim of developing composite breed from Holstein Frisian-sire and Arsi-dam breeds. The Arsi cows were purchased from highlands of Arsi zone and lowland agro-ecologies of Arsi and East Shoa zones. All cows were kept under similar management conditions. The cows having permanent teeth were taken for linear measurements. Accordingly, 144 and 78 cows were represented from lowland agro ecology and Highland agro-ecologies respectively. Moreover, thirty four one to three years old female calves which were born from this herd were included in study.

2.3 Measurement of Structural Traits

Twenty two structural traits were considered during observational survey. Namely: height at wither, hip height, chest depth, chest width, rump width, heart girth, flank girth, body length, rump length, neck length, neck circumference, ear length, horn length, face length, muzzle circumference, forehead width, pelvic width, tail length, cannon bone length**,** cannon bone circumference, hock circumference and body weight.

The physical measurements such as height at wither (HW), rump height (HR), chest depth (CD), chest width (CW), rump width (RW) and rump length (RL) were measured using graduate measuring sticks whereas heart girth (HG), flank girth (FG), body length (BL), neck length (NL), neck circumference (NC), ear length (EL), horn length (HL), face length (FL), muzzle circumference (MC), tail length (TL), cannon bone length (CBL), cannon bone circumference (CBC), hock circumference (HC) were measured using plastic measuring tape. The pelvic width (PW) and forehead width (FW) measurement were assessed using a calibrated wooden caliper. Body weight (BW) of cows was taken by standard weighing scale.

2.4 Structural Indices

The structural indices were calculated from structural traits as follows [7,9-11]:

Depth index =chest depth/height at wither,

Height index = height at withers/body length,

Rump length = rump length/body length

Body index = body length/heart girth

Weight index = ((body length x chest depth) x ((rump width + chest width)/ 2)/ 1050))

Relative cannon length = cannon bone circumference/ withers height

Body ratio index = height at withers/height at rump

DOI: http://dx.doi.org/10.36956/njas.v4i1.429

Over increase index = height at rump/height at withers.

2.5 Statically Analysis

Structural traits were analyzed by T-test of SPPS version twenty four. The Pearson's correlation among various structural traits was estimated. The model used for the analysis of correlations among various structural traits was estimated. The model used for the analysis of structural measurement was: $y_{ijk} = \mu + a_i + e_{ij}$

Where, Y =*is the phenotypic observation for one of the twenty two structural traits*,

μ=*is over all mean*,

a_i = *fixed effect of ith agro-ecology*, while

e_{ij} = *is random residual error associated with each observation*.

3. Results and Discussions

3.1 Structural Traits

Structural traits of cows and heifers are listed in Table 1. The height at wither, height at rump, chest depth, rump width, heart girth, flack girth, body length, rump length, neck length, mouth circumference, pelvic width, body weight, cannon bone circumference and hock circumference had significant different across agro ecologies when chest width, neck circumference, ear length, horn length, face length and cannon bone length had not showed significant different at $P<0.05$.

The height at wither of cows are presented in Table 1. The observed average value of height at wither of Arsi cows was shorter than Begait cows that reported by Teweldemedhn and Selam [12] while, it was similar with report of Dessalegn *et al.* [13] for Arado cows. However, the average height at wither obtained was taller than Malle cows [14]. The average height at rump of Arsi cows was shorter than findings of Dereje[15] for Horro cows. The observed value of height at rump was taller than Malle cows that reported from South Omo of Ethiopia [14].

Height at wither and height at rump are important as they determine how tall the animals are [16]. The height at wither and hip height are important skeletal measurements, which are associated with the skeletal dimension of the cattle. Some study indicated that animals adapted to the hot and humid climate have shorter height at wither while those adapted to the arid climate with sparse vegetation cover have higher height at withers and longer limbs [17].

The average value of chest width obtained in this study is lower than those reported by Demerew *et al.* [14] for Malle cows but higher than those reported by Worku [16] for Sheka cows. Further study indicated that Arsi cows have lower chest depth than Fogera cows [18]. The average chest depth of Arsi cows was higher than those reported by Worku [16] Sheka cows. The animals chest depth and chest width are correlated with the pleural capacity. Both traits are correlated with chest girth of animals and therefore have immense economic importance.

Study results indicated that Arsi cows have lower heart girth than those reported by Teweldemedhn and Selam [12] for Begait cows; Fasil and Workneh [19] for Fogera cows. However, it was observed that Arsi cows had higher heart girth than Arado cows [13]. The observed value for heart girth was similar with the finding of Chencha *et al.* [20] for Goffa cows. Cattle with low chest girth usually have lower body weight as the pleural cavity houses many of the vital organs and the development of these organs influences their body weight[21].

Values for average body length of Arsi cows are lower than those results reported by Shiferaw [22]; Getinet *et al.* [23] for Kereyu and Ogaden cows, respectively. The observed average body length was longer than Arado cows [13]. Cows with longer body usually have better potential as meat animals provided that they are properly managed. Body length is correlated with the body weight of cattle [6]. Cattle with large skeletal dimensions fetch higher price/value when compared to those with shorter skeletal dimensions [3]. But cattle with short skeletal dimensions require low space and maintenance cost. The rump length of cows in the current study is lower than those reported by Abdulmojeed *et al.* [24] for Bunaji and Red Angus cattle. The rump length has a significant importance for livestock as cows with optimal rump length usually have lower incidences of abortion and dystocia. This is so because of the fact that the fetus gets enough space to grow.

The average value of rump width observed for cows in this study was higher than what was reported for Mursi cows [25] but lower than those reported for Sheka cows [16]. It has been reported that cattle with narrower pelvic girth are prone to birth defects and that the trait shows sexual dimorphisms with the values being higher in females than in males [12]. Average values for pelvic width of Arsi cows is in close accordance with the finding of Dessalegn *et al.* [13] for Arado cows. However, the values are lower than those reported by Fasil and Workneh [19] for Fogera cows.

Forehead width is one of the important features defining a breed. While the head width of beef breeds of cattle are wider than that of the dairy breeds, there exists sexual dimorphism for this trait too [21]. The values pertaining to forehead width for the Arsi cows is higher than those for Sheka cows [16] but lower than those for Begait cows [21].

 DOI: http://dx.doi.org/10.36956/njas.v4i1.429

Table 1. Structural traits of cows and heifers (Mean ± SE)

	Structural traits (cm)										
	HW	***HR***	***CD***	***HG***	***FG***	***BL***	***RL***	***NL***	***MC***	***PW***	***BW(kg)***
Highland cows	108.3±0.5	113.6±0.4	56.3±0.3	143.3±0.8	147.5±0.9	119.6±0.7	36.5±0.2	34.9±0.3	38.7±0.3	32.1±0.3	223.4±2.99
Lowland cows	106.3±0.3	111.7±0.3	55.3±0.2	139.8±0.6	143.7±0.7	116.8±0.4	35.8±0.1	33.8±0.2	37.8±0.2	31.0±0.2	211.8±2.24
P values	*0.001*	*0.001*	*0.002*	*0.001*	*0.001*	*0.001*	*0.009*	*0.006*	*0.003*	*0.001*	*0.002*
Overall mean	107±0.3	112.4±0.3	55.6±0.2	141.1±0.5	145.1±0.6	117.8±0.4	36.1±0.1	34.2±0.2	38.2±0.1	31.41	215.98±1.8
Heifer	102.6±3.4	109.4±2.4	48.7±2.5	125.9±4.7	128.6±5.7	107.6±6.1	32.5±1.4	30.9±2.8	33.9±1.5	10.1±1.1	156.8±14.8
	Structural traits (cm)										
	CW	***RW***	***NC***	***EL***	***HL***	***FL***	***FW***	***TL***	***CBL***	***CBC***	***HC***
Highland cows	30.1±0.3	38.5± 0.3	71.7±0.8	18.9±0.2	27.5±0.6	40.6±0.2	17.5±0.1	73.5±0.7	18.6±0.1	13.7±0.1	23.7±0.1
Lowland cows	29.5±0.2	35.8±0.2	70.5±0.5	19.1±0.1	27.5±0.3	40.5±0.2	17.4±0.1	73.3±0.5	18.5±0.1	13.5±0.1	23.3±0.1
P values	*0.12*	*0.04*	*0.12*	*0.73*	*0.99*	*0.74*	*0.41*	*0.81*	*0.51*	*0.03*	*0.004*
Overall mean	29.7±0.2	36.1±0.2	70.9±0.4	19±0.1	27.5±0.4	40.5±0.1	17.4±0.1	73.3±0.4	18.6±0.1	13.58	23.4±0.1
Heifer	24.7±1.7	30.9±1.7	62.4±4.7	19±1.5	37.7±1.7	37.7±1.7	15.8±1	69.3±7.2	18.6±0.7	12.8±0.6	22.7±0.7

Some structural values of cows within the same column not vary significantly at P<0.05

The average value of the cannon bone length of Arsi cows was shorter than that of Horro cows [15]. The cannon bone circumferences observed for cows in this study were also narrower when compared to that reported for Begait cows [21]. The animals with narrow cannon bone circumference usually have lower body weight as the space for muscle attachment is less in such types of animals. The cannon bone circumference observed for cows in this study are narrower than those reported by Dereje [15] for Horro cows but similar to those reported by Endashaw *et al.* [25] for Mursi cows.

The values pertaining to the neck circumference indicate that the neck is narrower when compared to that of the Begait breed [26], but wider than that of Malle cattle [14]. This may be ascribed to the breed character. Neck length is a trait which is correlated with the femineity and masculinity of cattle. The observed neck length of Arsi cow was shorter than that of the Begait cattle [12]. Neck length values are correlated with development of cervical vertebrae [16], which is helpful for draft purposes in cattle. Cows with long thin neck are usually preferred over those with short and thick necks [27].

3.2 Correlations of Structural Traits for Cows

The correlation of biometric traits cows are listed in Table 2. Height at wither, height at rump, chest depth, chest width, rump width, heart girth, flank girth, body length, mouth circumference, pelvic width, cannon bone circumference and hook circumference of the cows are positively correlated to each other and highly correlated ($P< 0.01$) to body weight. The findings indicated that rump length, neck length, neck circumference, ear length, horn length, face length, forehead width, tail length and cannon bone length have weak correlation coefficients to the live body weight.

The observed highest correlation between heart girth and body weight is in close accordance with the finding of Rashid *et al.* [28] for Brahman crossed bred and Musa *et al.* [29] for Kenana cattle. Bivariate correlation indicated that flank girth was the second highest correlated trait with live body weight than other structural traits. It was observed that hock circumference, chest depth, hip height, cannon circumference, chest width, weight at withers and rump width were highly correlated to body weight in a decreasing manner. It was also observed that ear length, horn length and dewlap width were not significantly correlated ($P< 0.01$) to body weight which might be due to their less association with body weight.

Table 2. Correlation between body weight and structural traits for cows

Traits	BW	Traits	BW	Traits	BW	Traits	BW
HW	.602	FG	.736	RL	.441	FL	.416
HR	.644	BL	.510	NL	.290	FW	.339
CD	.652	MC	.528	NC	.336	TL	.184
CW	.607	PW	.581	CBL	.207		
RW	.599	CBC	.608	EL	.051		
HG	.818	HC	.675	HL	.082		

All Correlation between body weight and structural traits are significant at 0.01 level (2-tailed).

DOI: http://dx.doi.org/10.36956/njas.v4i1.429

3.3 Body Weight Prediction

3.3.1 Simple Linear Equation

The simple regression models are presented in Table 3. Simple linear regression results pertaining to the structural measurements indicated that cows from highland agro-ecology had lower coefficient of determination when compared to those from lowland agro-ecology. The multiple linear equations have more coefficient of determination in predicting the body weight of Arsi cows. However, taking multiple measurements in bovines are problematic especially under field conditions where the infrastructure is wanting and there are lack of crushes and appropriate livestock handling tools [30]. Under such condition, single trait is preferable to predict body weights. The study showed that among the structural measurements, the best treat was the heart girth measurements, which are in close accordance with those of Lukuyu *et al.* [6]; Rashid *et al*. [31]. This may be ascribed to the fact that the thoracic cavity holds some of the most vital organs of the animals and weight of these organs are highly correlated with the live weight of the animals [17].

Table 3. Simple linear regression of weight on heart girth for the cows and heifers

Cattle	R^2	Regression equation
Highland agro-ecology cows	0.777	-195.63 + 2.90(x)
Lowland agro-ecology cows	0.826	-232.65 + 3.18(x)
Combined equations	0.818	-221.005 + 3.10(x)
Heifers	0.723	-188.452 + 2.75(x)

x: heart girth

3.3.2 Multiple Linear Equations for Cows

Stepwise multiple linear regression models of cows are presented in Table 4. The coefficient of determination of multiple linear regressions increases as number of traits is added to models. The study indicated that single trait linear equation for Arsi cows has low coefficient compared to the multiple traits. The equation developed from heart girth alone has low coefficient of determination than the equation developed from rump width and heart girth. Furthermore, the study indicated that the accuracy of body weight prediction increases as the number of morphometric traits included in the linear equation increases. Both these scenarios are in close accordance with the finding of Rashid *et al*. [31]. However, as livestock handling is difficult in rural areas due to lack of restraining equipment and due the behavior of zebu breed [30]; it becomes difficult to assess multiple measurements for an animal. Hence, relying on any single trait measurement which is highly correlated with body weight [32] is inevitable.

3.3.3 Curve Fit Regression Equations

Linear and non linear regression models of few structural are listed in Table 5. The study indicated that heart girth was the best body weight predictor followed by flank girth and hock circumference in that order. Their respective non-linear regression equations have similar coefficient of determination with simple linear regression. Particularly, the quadratic regression equation has almost equal coefficient of determination to the linear equation. However, the result of this study disagrees with that reported by Banerjee *et al.* [30], who stated that the quadratic regression equations have a better accuracy when compared to the linear measurements for Borana bulls. Further this study indicated that the single linear and non-linear equations have lower accuracy when compared to multiple linear regression equations.

Table 4. Stepwise multiple linear regression models

R^2	Multiple linear equations
0.818	-221 + 3.1HG
0.848	-256.1 + 2.6HG + 2.87RW
0.869	-310.6 + 2.2HG + 2.6RW + 8.85CBC
0.881	-318 + 1.68HG + 2.45RW + 7.74CBC + 0.74FG
0.887	-322.5 + 1.52HG + 2.4RW + 6.9CBC + 0.66FG + 1.5PW
0.892	-319.1 + 1.26HG + 1.87RW + 7CBC + 0.7FG + 1.5PW + 1.42CW
0.896	-357.7 + 1.1HG + 1.9RW + 6CBC + 0.68FG + 1.3PW + 1.5CW + 0.76HR

Table 5. Linear and non-linear regression models for different traits

Regression	Heart girth		Flank girth		Hock circumference	
	R^2	Equation	R^2	equation	R^2	Equation
Linear	0.818	-221.005 + 3.098(x)	0.736	96.14 + 0.226(x)	0.675	17.95 + 0.025(x)
Logarithmic	0.817	-1961.031 + 439.99ln(x)	0.734	-120.268 + 49.42ln(x)	0.669	-6.25 + 5.53ln(x)
Inverse	0.815	658.186 - 62219.6(1/x)	0.728	194.5-10529.9(1/x)	0.659	28.91-1169.1(1/x)
Quadratic	0.818	-106.375 + 1.486(x) + $0.006x^2$	0.736	91.42-0.27(x) + $-9.69x^2$	0.677	20.4+ 0.003(x) + $5.1x^2$
Exponential	0.813	29.476 + $e^{0.14(x)}$	0.718	103.45 + $e^{0.002(x)}$	0.674	18.52 + $e^{0.001(x)}$

Notice x = heart girth, flank girth, hock circumference

DOI: http://dx.doi.org/10.36956/njas.v4i1.429

3.4 Structural Indices

The structural indices of Arsi cows are listed in Table 6. Weight index was significantly different ($P<0.05$) for cows in the two agro-ecologies. Depth index, rump length index, body index, relative cannon thickness index, body ration index and over increase index were not statically different between agro-ecologies.

The rump length index of the Arsi cows is quite smaller when compared to that of the other breeds. This is an indication of the compactness of the Arsi cows [7]. The results pertaining to the weight index showed that the weights of the Arsi cows are lower than that of the Malle cattle [14]. The difference in body weight index may be associated with the difference in agro-ecologies from where the cows came.

Table 6. Structural indices of the cows

	Index							
Location	**DI**	**HI**	**RLI**	**BI**	**WI**	**RCT**	**BRI**	**OII**
Highland	0.52	0.91	0.31	0.84	214.24[a]	0.13	0.95	1.05
Lowland	0.52	0.91	0.31	0.84	201.43[b]	0.13	0.95	1.05
Overall	0.52	0.91	0.31	0.84	205.93	0.13	0.95	1.05

DI: depth index, HI: height index, RLI: Rump length index, BI: body index, WI: body weight index, RCT: relative cannon thickness, BRI: body ratio index, OII: over increase index

The values observed for height and over increase indexes in this study were lower than those reported by Tariku [33]. The values for the over increase and body ratio indexes showed that the hind quarters of the cows are raised. The relative cannon thickness index obtained for cows in this study indicated that their cannon are quite narrow. The animals that have thin cannon bone are expected to be less masculinity and have low carcass yield [10]. The value for depth index was higher than that of the Sheka cows [16]. An observed value shows that chest depth was half height at wither.

4. Conclusions and Recommendation

The highland Arsi cows have wider chest and pelvic bone, longer rump and body length, bigger heart and flank girth, thicker cannon and hock bone, taller hip and heavier body than lowland Arsi cows. This might be correlated to the ecological adaption of the cattle. These variations in structural traits indicate the possibilities to undertake within breed selections.

The regression equations need to be validated at on-farm level to predict body weight of female Arsi cattle. Measuring chart tape should be developed to predict the body weight from heart girth of Arsi cows and heifer at field condition where there is no access of weighing scales.

Depth index revealed that chest depth is half of the height at wither. This might show the body is balanced which may help animal to walk long distance. Thus might reason why animals distributed in areas of the country. Over-increase index indicated that the hip of Arsi cows is taller by 5% than height at wither. Further, rump length index indicated that rump length is 31% of the body length. Indices indicate that Arsi cows have compact and light which implies that the breed is suitable for crossing by virtue of being small dairy type breeds.

References

[1] Pundir, R.K., Singh, P.K., Singh, K.P., Dangi, P.S., 2011. Factor analysis of biometric traits of Kankrej cows to explain body conformation. Journal of Animal Science. 24, 449-456.

[2] Kugonza, D.R., Nabasirye, M., Mpairwe, D., Hanotte, O., Okeyo, A.M., 2011. Productivity and morphology of Ankole cattle in three livestock production systems in Uganda. Animal Genetic Resources. 48, 13-22.

[3] Alsidding, M.A., Baker, S.A., Galal, M.Y., Mohammed, A.M., 2010. Phenotypic characterization of Sudan zebu cattle. Research Journal of Animal and Veterinary science. 5(2), 10-17.

[4] Ozkaya, S., Bozkur, Y., 2008. The relationship of parameters of body measures and body weight by using digital image analysis in pre-slaughter cattle. Arch. Tierz., Dummerstorf. 51(2), 120-128.

[5] Sandip Banerjee, Mohamed Beyan Ahmed, Girma Tefere, 2014. Studies on morphometrical traits of Boran bulls reared on two feedlots in Southern Ethiopia. Published online by Cambridge University Press. DOI: https://doi.org/10.1017/S2078633614000095.

[6] Lukuyu, M.N., Gibson, J.P., Savage, D.B. et al., 2016. Use of body linear measurements to estimate liveweight of crossbred dairy cattle in smallholder farms in Kenya. SpringerPlus 5, 63. DOI: https://doi.org/10.1186/s40064-016-1698-3.

[7] Alderson, G.L.H., 1999. The development of a system of linear measurements to provide an assessment of type and function of beef cattle. Animal Genetic Resources Information. 25, 45-55.

[8] DAGRIS (Domestic Animal Genetic Resources Information System), 2018. International Livestock Research Institute, Addis Ababa, Ethiopia. Accessed date, April 9, 2018 http://eth.dagris.info/species/85/breeds.

[9] Salako, A.E., 2006. Principal Component Factor Analysis of the Morpho-structure of immature Uda

DOI: http://dx.doi.org/10.36956/njas.v4i1.429

Sheep. International Journal of Morphology. 24(4), 571-774.

[10] Chacon, E., Macedo, F., Velazquez, F., Rezende Paiva, S., Pineada, E., Mc Manus, C., 2011. Morphological measurements and body indices for Cuban creole goats and crossbreds. R.Bras. Zootec. 40(8), 321-327.

[11] Pares-Casanova Pere, M., Mwaanga, E.S., Caballero, M., Sanbate, J., Valenzuela, S., 2013. Biometrical multivariate Study of the Indigenous fat-tailed Sheep. International Journal of Livestock Production. 4(9), 148-154.

[12] Teweldemedhn Mekonnen, Selam Mesere, 2020. Characterization of Begait cattle using morphometric and qualitative traits in Western Zone of Tigray, Ethiopia. International journal of livestock production. 11(1), 21-33.

[13] Dessalegn Genzabu, Mokonnen Hailemeriam, Kelay Behlihu, 2012. Morphometric Characteristics and Livestock keeper perception of Arado cattle in Northern Tigray, Ethiopia. Livestock Research for Rural Development. Volume 24, Article #101. Retrieved May 15, 2018, from http://www.lrrd.org/lrrd24/1/balu24121.html.

[14] Demerew Getaneh, Sandip Banerjee, Mestawet Taye, 2019. Morphometric traits and structural indices of malle cattle reared in the south Omo zone of southwest Ethiopia. International Journal of Veterinary Sciences Research. 5(2), 32-47.

[15] Dereje, B., 2015. On farm phenotypic characterization of indigenous cattle and their production systems in BakoTibe and Gobu Sayo districts of Oromia region, Ethiopia. MSc. thesis. Haramaya University, Ethiopia. pp. 68.

[16] Worku Masho, 2017. Assessment of type, function and traditional selection methods of indigenous cattle reared in Sheka Zone, South West Ethiopia. MSc Thesis. Hawassa University. Hawassa. pp 107.

[17] Mwacharo, J.M., Okeyo, A.M., Kamande, G.K., Rege, J.E.O., 2006. The small East African shorthorn zebu cows in Kenya. I: Linear body measurements Trop Anim Health Prod. 38, 65-74. DOI: https://doi.org/10.1007/s11250-006-4266-y.

[18] Zewdu, W., Workneh Ayalew, J., Hedge, B.P., 2008. Mehibere-Silassie Composite; some new cattle breed type in north western Ethiopia. Journal of Animal production. 8(1), 39-52.

[19] Fasil Getachew Kebede, Workneh Ayalew, 2014. On-farm phenotypic characterization of indigenous cattle populations of Awi, East and West Gojjam Zones of Amhara Region, Ethiopia. Research Journal of Agriculture and Environmental Management. 3(4), 227-237.

[20] Chencha Chebo, Workneh Ayalew, Zewdu Wuletaw, 2013. On farm phenotypic characterization of indigenous cattle population of Gamo Goffa Zone. Animal Genetic Resources. 52, 71-82.

[21] Tewelde Gebru, SintayehuYigrem, Sandip Banerjee, 2017. Some morphometrical, production and reproduction in Begait cattle reared at Tigray Region of Ethiopia. Wayamba Journal of Animals Science. 1498735834, 1571-1585.

[22] Shiferaw, G., 2006. In-Situ characterization of Kereyu Cattle Type in Fentalle District of Oromia Region, Ethiopia. MSc. Thesis. Haramaya University, Ethiopia. pp. 122.

[23] Getinet, M., Workneh, A., Hegde, B.P., 2009. Growth and reproductive performance of Ogaden cattle at Haramaya University, Ethiopia. Ethiopian Journal of Animal Production. 9(1), 13-38.

[24] Abdulmojeed, Y., Kingsley Omogiade, I., Hadiza Salihu, H., Matthew, W., Samuel, A., 2010. Multivariate analysis of phenotypic differentiation in Bunaji and Sokoto Gudali cattle. Acta Argiculturae Slovenica. 96(2), 75-80.

[25] Endashaw Terefe, Tadelle Dessie, Aynalem Haile, Wudyalew Mulatu, Ally Okeyo Mwai, 2015. On-farm phenotypic characterization of Mursi cattle in its production environment in South Omo Zone, Southwest Ethiopia. Animal Genetic Resources. 57, 15-24.

[26] Mulgeta Ftiwi, BerhanTamir, 2015. Phenotypic characterization of indigenous cattle in Western Tigray, Northern Ethiopia. The Journal of Agriculture and Natural Science. 2(1), 343-354.

[27] Takele, T., 2005. On-farm Phenotypic Characterization of Sheko Breed of Cattle and their Habitat in Bench Maji Zone, Ethiopia. MSc Thesis. Haramaya University. Ethiopia. pp. 105.

[28] Rashid, M.M., Hoque, M.A., Huque, K.S., Bhuiyan, A.K.F.H., 2016. Prediction of live weight for Brahman crossbred cattle using linear body measurements in rural area. Adv. Anim. Vet. Sci. 4(2), 99-106.

[29] Musa, A.M., Elamin, K.M., Mohammed, S.A., Abdalla, H.O., 2011. Morphometric traits as indicators for body weight in Sudanese Kenana cattle. Online J. Anim. Feed Res. 1(5), 218-222.

[30] Sandip Banerjee, Mohammed Beyan, GirmaTerefe, 2016. Predictions of body weight of boran bulls reared at two feedlots of southern Ethiopia, using linear and curve fit regressions equations.WayambaJournalof-AnimalScience–ISSN:2012-578X; P1467-P1474.

 DOI: http://dx.doi.org/10.36956/njas.v4i1.429

[31] Md. Mahbubur Rashid, Md. Azharul Hoque, Khan Shahidul Huque, Md. Azharul Islam Talukder, Fazlul Huque Bhuiyan, A.K., 2015. Morphometric characterization of Brahman crossbred cattle and prediction of live weight using linear body measurements. Asian J. Med. Biol. Res. 1(3), 569-577. DOI: https://doi.org/10.3329/ajmbr.v1i3.26480.

[32] Gunawan, A., Jakaria, 2014. Application of Linear Body Measurements for Predicting Weaning and Yearling Weight of Bali Cattle. Animal Production. 12(3), 163-168.

[33] Tariku Woldeyohannes, 2018. Production system, Morphological characterization and Structural indices of indigenous cattle in Hadiya Zone, Southern Ethiopia. pp 94.

DOI: http://dx.doi.org/10.36956/njas.v4i1.429

NASS Journal of Agricultural Sciences
http://ojs.nassg.org/index.php/NJAS

ARTICLE

Indigenous Knowledge on Production and Utilisation of Termite (*Isoptera*) in Western Kenya

Vugutsa J.E.[1*] Mosi, R.O.[2] Wambui, C.C.[3]

1. Vihiga County Government, Maragoli, Kenya
2. Jaramogi Oginga Odinga University of Science and Technology (JOOUST), Department of Plant Animal and Food Science, Bondo, Kenya
3. Maseno University, Department of Animal Science, Maseno, Kenya

ARTICLE INFO

Article history
Received: 19 July 2021
Accepted: 21 December 2021
Published Online: 4 January 2022

Keywords:
Knowledge
Characteristics
Harvesting
Utilisation
Termites

ABSTRACT

The study sought to assess the level of knowledge on the utilization of termites, harvesting methods and characterise local edible termite species. Focus group discussion with key informants was used to collect data that was analysed using SPSS Version 21.0 to generate descriptive statistics. Results indicated different levels of termites' utilisation where 45% of farmers use alates as food, 35% as feed for chicks and quails, while 20% use the queen to fatten young bulls. Majority of farmers (40%) prefer the use of termites as feed because it is readily available, followed with 20% that use it because of nutritive value,10% relate its use with better taste of poultry products, 5 % associate termite use in enhancing early maturity weight while 5% said it improves growth and strength of bulls. On harvesting, three methods are commonly used with most farmers (45%) using underground trapping method, (35%) use above ground trapping method but 20% use mound excavation. Varied plant materials are used as attractants and the effect is more when combined with dry cow dung. Farmers further characterised species based on time of emergence of alates and habitat's physical features. Most respondents (45%) associated: big mounds with *Macrotermes bellicosus* (Mafendete); small mount to *Macrotermes subhyalinus (Kitunda);* presence of open big tunnels with *Coptotermes millitaris (Riamke)* while seasonal gallaries and small tunnels was a confirmatory feature of either *Pseudocanthotermes militaris* (Chiisiisi) and *Pseudocanthotermes spiniger (*Maburi). The study demonstrates the richness in indigenous knowledge on techniques of termite production and utilization.

1. Background Information

The high cost of protein for use as food and feed coupled with overreliance on use of silver cyprinid (*Rastroneobola argentae*) has evoked the need to explore suitable, available and affordable alternative protein sources. Currently, insects are being explored due to their established nutritional value and abundancies [1]. Unfortunately, there has been paucity of information on their general use, acceptability and harvesting. Their inclusion in poultry diet is likely to form a suitable protein source as opposed to the conventional use of Silver

**Corresponding Author:*
Vugutsa J.E.,
Vihiga County Government, Maragoli, Kenya;
Email: jejosken@gmail.com

 DOI: http://dx.doi.org/10.36956/njas.v4i1.424

Cyprinid/Omena (*Rastroneobola argentae*) which has competing demands by human and livestock for food and feed. Currently about 200 million people in Africa rely on fish whose supply is declining thus negatively impacting on per capita consumption [2]. Fortunately, termites have previously been used as chicken feed in many countries with proven ability of being palatable and positively impacting on growth and carcass characteristics to birds [3]. This hence forms a basis of reconsidering its inclusion in poultry diet. However there has been a major setback on raising quantities due to seasonality on emergence of alates, poor method of utilization and harvesting techniques [4]. In Bukina Faso, time, unavailability and insufficient knowledge on harvesting technique was a major hindrance towards its effective use as poultry feed [5]. Subsequent study on harvesting method further revealed that harvesting method varies with termite genius, region and season [6]. Due to different geographical regions and difference in termite distribution and diversity, there is likelihood of uniqueness in suitability of method to adopt. This study seeks to ascertain on a method that will suit Kenya related conditions as well as build on indigenous knowledge for easy adoption.

In Western Kenya, there exist various types of termite's species and some have in the recent past been exploited by smallholder farmers as special feed for chicks and quails. A number of farmers have been harvesting soldiers and workers and directly feeding their birds. However, there is still paucity of information and documentation regarding their preference, harvesting technique, material used scope of their use. It is against the background that the study was undertaken to evaluate the knowledge of utilisation and production. This will help to validate and document on above issues for purpose of their effective and sustainable use as suitable substitute to silver cyprinid.

2. Methodology

2.1 Experimental Site

Vihiga County was purposefully used for the study due to its; proximities with the researcher, availability of equipment, experimental materials and the social cultural norms of the community. Termite harvesting techniques were done in County since a section of the community seemed to have traditional knowledge on their harvesting and utilization as food and feed. The County covers a total area of 531.0 Km^2 and has five Sub-Counties (Emuhaya and Luanda Sub-Counties at 173.5 Km^2, followed by Hamisi 156.4 Km^2, Sabatia 110.9 Km^2 and Vihiga at 90.2 Km^2). The County is categorized into two main agro-ecological zones; the upper and lower midland Vihiga County covers a total area of 563.0 Km^2 with an estimated population of 554,622.

Figure 1. Map of Vihiga County

2.2 Study Design

Focus group discussion (FGD) with key informants was used to collect data on indigenous knowledge on harvesting and utilization of termites. The design enabled to get in-depth inquiry as well as have informed theory and practices.

2.3 Sampling and Sample Size

Purposive sampling was used to obtain 96 key informants drawn from household of farmers who had majored in quail farming and known to have knowledge on termite utilization. The number of interviewees was chosen based on percentage of farmers harvesting termites in accordance with Vasileiou [7] using Cochran's formula on determination of sample size since information on number of farmers harvesting termites was unknown.

Sample size (n)

$$no=\frac{Z2pq}{e2}$$

Where

Confidence level=		95%
Precision	=	0.1
no	=	Sample size
p	=	estimated proportion of an attribute that is present in a population
e	=	desired level of precision
q	=	1-p
no	=	$\frac{1.96^2(0.5)(0.5)}{0.1^2}$
No	=	96.04

DOI: http://dx.doi.org/10.36956/njas.v4i1.424

2.4 Data Collection

Data were collected on farmer's socio-demographic profiles, utilization of termites, termite species, termite habitats, and harvesting techniques. The pre-test was used to assess the ease of understanding of the questions by respondents and their appropriateness under the study context.

2.5 Data Analysis

Data analysis on descriptive statistics was done with the aid of the Statistical Package for Social Sciences (SPSS) Version 21.0.

3. Results

3.1 Socio-demographic Profile

Socio-demographic profile of respondents revealed that 70% of the community engaged in termite harvesting were male while only 30% were female. The most (55%) age group engaged in termite harvesting was between 36 to 55 years. This was followed by age group of between 18 to 35 years (25%), while the lowest was age group above 56 years (20%) (Table 1).

Table 1. Socio-demographic profiles of community engaged in termite harvesting in Vihiga County (n=96)

Variables	Categories	Response (%)
Gender	Male	70
	Female	30
Age	18-35	25
	36-55	55
	≥56	20

3.2 Termite Use

Most of the respondents (45%) indicated that the most common use of termites is as source of food, especially for the case of alates. Others (35%) indicated that termites such as soldiers and workers are used as feed especially for poultry. The rest of the respondents (20%) indicated that termites like queen are used to fatten young bulls (Table 2). Based on the importance of termites, most of the respondents (40%) indicated that they are mainly used as a cheap source of food or feed, while 20% of the respondents indicated that they are a rich source of nutrients. This was followed by 10% of the respondents who indicated that termites can help to improve taste of poultry meat, enhance quality of eggs or boost immunity of poultry. The lowest percentage of respondents (5%) indicated that termites are used for faster development of poultry or improve growth and strength of bulls (Table 2).

Table 2. Termite use by community engaged in termite harvesting in Vihiga County (n=96)

Variables	Categories	Response (%)
Knowledge on use of termites	Soldiers and workers used to feed poultry	35
	Alates used as food	45
	Queen fed to young bulls	20
Importance of termites as feed/ food	Rich in nutrients	20
	Faster development of poultry	5
	Cheap source of food or feed	40
	Improve taste of poultry meat	10
	Improve growth and strength of bulls	5
	Enhance quality of eggs	10
	Boost immunity of poultry	10

3.3 Termite Species and Preference

Based on indigenous knowledge on existing termite species and their characteristic features, the respondents revealed that the alates of *pseudocanthotermes millitaris and Macrotermes bellicosus* were the most commonly known termite (40%) (Table 3). They indicated that the alates emerge as from noon on a sunny day following previous rain and at night respectively. The second commonly known termite was *Macrotermes subhyalinus* (25%) and *pseudocanthotermes spininger* (25%), which emerge in the evening. The least commonly known termite was *Coptotermes millitaris* (10%), that emerge anytime during light showers (Table 4). The reason for the preferred termite species as food or feed was because they are delicious (40%), while others (35%) preferred the termite species because they are abundant and the rest (25%) preferred termite species because they do not injure poultry especially chicks (Table 4).

Table 3. Summary table on available edible species by local name

No.	Scientific Name	Local Name
1	*Macrotermes bellicosus*	Mafendete
2	*Macrotermes subhyalinus*	Kitunda
3	*Pseudocanthotermes millitaris*	Chiisiisi
4	*Pseudocanthotermes spininger*	Maburi
5	*Coptotermes millitaris*	Mamke

3.4 Termite Habitat

Majority of the respondents indicated that soils with minimal or no disturbance are places where termites were most likely (45%) to be found. This was followed by well-drained soil (15%) and then along the roads (10%) or near water source (10%) (Table 6). Based on features used to

DOI: http://dx.doi.org/10.36956/njas.v4i1.424

determine presence of termites, mounds were the most likely (45%) feature for the determination of presence of termites. This was followed by galleries (25%), then openings (15%) or tunnels (15%) (Table 6).

Table 4. Knowledge on existing termite types by community engaged in termite harvesting in Vihiga County (n=96)

Variables	Categories	Response (%)
Indigenous knowledge on existing termite types (local names) and characteristic features	*Coptermes millitaris* - alates emerge anytime on slight rain	40
	Pseudocanthoterms millitaris -alates emerge at noon in sunny day following previous rain	25
	Macrotermes bellicosus -alates emerge at night	25
	Marcotermes subhyalinus and *Pseudocanthotermes spiniger* -alates emerge in the evening	10
The reason for the most preferred termites as feed/ food	They are abundant and does not injure the poultry	25
	They are abundant	35
	Delicious	40

Table 6. Knowledge on places most likely to find termite by community engaged in termite harvesting in Vihiga County (n=96)

Variables	Categories	Response (%)
Places likely to find termites	Well-drained soil- *Pseudocanthotermes militaris*	20
	Soils with little or no disturbance- *Pseudocanthotermes militaris*	45
	Soils where no chemicals are used- Pseudocanthotermes militaris	15
	Along the roads- *Macrotermes bellicosus* and *marcotermes Subhyalinus*	10
	Near water source- *Coptotermes millitaris*	10
Features used to determine presence of termites	Mounds (*Macrotermes bellicosus* and *Macrotermes subhyalinus*	45
	Galleries (*Pseudocanthotermes militaris*)	25
	Openings (*Pseudocanthotermes millitaris*)	15
	Tunnels (*Coptotermes millitaris*)	15

3.5 Termite Harvesting

Based on knowledge of termite harvesting, most respondents (25% each) had termite harvesting experience of 11 to 20 years or 21 to 30 years. This was followed by less than 5 years or 5 to 10 years at 15% each and then those having termite harvesting experience of between 31 to 40 years and the lowest percentage (5% each) of respondents indicated that they had 41 to 50 years or over 50 years of termite harvesting experience (Table 7). Based on season for harvesting termites, majority (40%) reported that termites are mostly harvested during the rainy season particularly alates, followed by dry season (35%) and lastly 25% reported that they harvest termites throughout the day. Majority of the respondents reported that the best time of the day for harvesting termites was reported to be in the morning (45%). This was followed by respondents who indicated that termites can be harvested anytime of the day (25%), while 20% of the respondents indicated that termites are best harvested at noon and the rest (10%) of the respondents indicated that the best time of harvesting termites is evening. The most preferred termite harvesting method by the majority of the respondents (45%) use above ground, followed by below ground (30%), while the rest (25%) indicated digging through the mound (Figure 2).

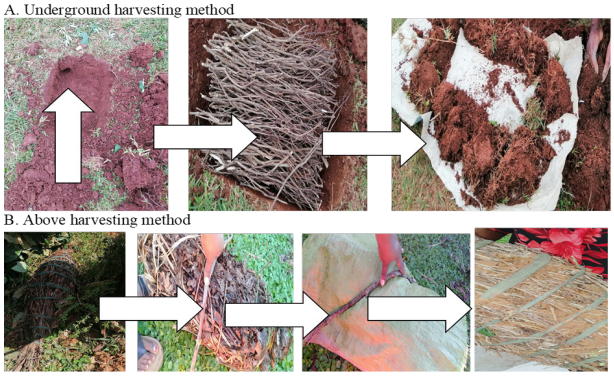


Figure 2. Harvesting methods of termites

There were varied reasons on harvesting method of choice. Majority of farmers (30% each) preferred method of choice due to multiple harvest and high yields while 15% each indicated that the method was simpler and easy to separate termites from harvesting residuals materials but 10 percent attributed to ability of the method to capture a variety of termite species and caste (Table 7). Based on the materials used in the harvesting of termites, the most common one was the use of tea 30% maize stalk or cobs (20%), followed by use of dry couch grass (15%), Rattle weed (10%) cow dung (10%), dry eucalyptus back (5%), sugarcane (5%), others (5%). On preferred harvesting materials , farmers (35%) choose the material because of its ability to produce high, their reusability (20%), availability (15%), dry ability (15%), preferred by termites (10%), good trap (10%), attractants (5%).

DOI: http://dx.doi.org/10.36956/njas.v4i1.424

Table 7. Knowledge on termite harvesting techniques by community engaged in termite harvesting in Vihiga County (n=96)

Variables	Categories	Response (%)	Variables	Categories	Response (%)
Experience on termite harvesting techniques (years)	<5	15	Why the preferred method	Simple and easier	15
	5-10	15		Multiple harvest	30
	11-20	25		Higher yield	30
	21-30	25		Captures variety of termites	10
	31-40	10		Easy to separate termites	15
	41-50	5			
	>50	5	Materials used in the harvesting of termites	Dry eucalyptus back	5
				Cow dung	10
Season for harvesting termites	Throughout the year- solders and workers	25		Dry grass (couch grass)	15
	Rainy season- Riamke alates	40		Maize (stalk or cobs)	20
	Dry season	35		Rattle weed	10
				Tea (dry wood)	30
Best time of the day to harvest termites	Anytime	25		Sugarcane	5
	Morning	45		Others	5
	Noon	20			
	Evening	10	Why the preferred materials	Preferred by termites	10
				Good trap (couch grass)	10
Harvesting method preferred	Above ground	45		Availability	15
	Below ground	30		Attractants (cow dung)	5
	Digging through mound	25		Reusability	20
				Drying ability	15
				Yield	35

4. Discussion

The findings revealed that most edible termites' species in Western Kenya are subterranean termites. Termites are social insect that live in nest or colonies underground the soil whose society is highly integrated [8]. They are rarely seen above ground save for the period of flight for alates and workers during foraging whose presence is characterised by occasional galleries/ shelter tubes that appear on soil surface [8]. They prefer moist environment by leaving in soil or building of mud tunnels while foraging to prevent desiccation [8]. Farmers hence capitalise on the presence of galleries, mounds, and mud tunnels as appropriate bait site as well as guide in tracing the main nest. By composition, the caste termites obtained consisted of the winged termites known as alates (Chiiswa), and the wingless that consisted of soldiers (Tsindago) and workers (Amage). This conforms with subterranean type whose colony consist of a three-caste system of reproductive (consist of king, queen, alates, and nymph); soldiers and workers (pseudergates) with three forms of reproduction; primary, secondary and tertiary [8]. Reproductive males and females can be primary winged (alates/swarmer's) or secondary and tertiary that are wingless. The secondary and tertiary form a backup for the primary queen and king in case of death or injury. The workers forage for about 150 feet below and above ground in search of food by making interconnected feeding site. The nature of mound, positioning of nest, emergence of alates together with morphological features of alates, worker and soldiers were used in combination to characterise the termites by genus and assigning of a local name.

On emergence of alates, it was reported that different species emerge at different seasons and time of the day throughout the calendar year. The *Macrotermes bellicosus* were particularly known to emerge during long rains as from April to June. The alates of the species are the biggest and mainly collected by farmers for use as food. They emerge at night for maximum period of one hour from 2.00 am to 3.00 am in the morning. The soldiers and workers of the same spp. are also the largest (soldier- 2 cm long) in comparison with other species. The soldier and workers were mainly harvested as described below (underground method) and directly fed to chicks and quails as suitable source of protein. Although there were reported cases of injury to the birds by soldiers, which hence informs on the need to identify appropriate method of administering the protein source to birds as well as ascertain its nutritive values and correct levels of inclusion. Features used to confirm the emergence of alates was by drop of feathers and presence of paired termites in readiness to form a new colony. The paired alate consist of male and female reproductive that such

 DOI: http://dx.doi.org/10.36956/njas.v4i1.424

for nest in suitable environment. The flight/emergence of alates are triggered by previous day's rain followed with dry warm spell.

The *Macrotermes subhylanus* were also identified as available and edible species in the region. Their presence is characterised by small and loosely build mound as their nest. In comparison, their mature mound of the spp. is smaller (≤0.5 m) unlike the *Macrotermes bellicosus* whose mound is big (≥ 1 m) and compact. In addition, the soldiers and workers of the species are the smallest of all the available edible termite species in the region. Farmers mainly collect the alates between 6:30 to 7.00 pm. whose period of emergence is the shortest. Farmers prefer the species attributing it to be sweeter with 50% of respondents consuming it in raw nature.

Beside the mounds as characteristics features the community mentioned the existence of galleries mud walls and openings on soil surface as confirmatory sign of the presence of both *Pseudocanthotermes millitaris* and *Pseudocanthotermes* spiniger. It was further mentioned that the nest for the two spp. could not easily be traced unlike the earlier discussed that had mounds of which the primary reproductive (both the king and queen) could easily be found. The alates of the two were used as food and soldiers and workers which were morphologically identical were harvested and used to feed for chicks and quails. Despite the quantities harvested, the soldiers and workers were preferred as direct feed to chicks since there were no reported incidences of injuries. On time of emergence, the alates for *pseudocanthotermes millitaris* emerge for about 2hours on sunny day from noon 3.00 pm, following previous day's rain. For *Pseucocanthotermes subhyalinus*, the alates emerge for maximum period of 30 minutes in the evening as from 5.30 to 6 p.m again following previous days rain.

The last and fifth edible species identified was the *Coptotermes millitaris*. It was reported that the species is commonly found in cooler places near water sources. The major characteristic feature for their presence is several clustered open Tunnels ranging between 3 cm to 6 cm in diameter on which the termites make galleries. The presences of tunnels are indication of existence of nest underneath through which the primary reproductive termites (king and queen) are found. The alates are comparatively second biggest to *Marcotermes bellicosus* but greyish in colour. In addition, the alates emerge any time of the day during light showers. Their soldiers are workers have a light brown to cream head and mostly harvested by above method as described below. Most farmers the use of species as feed because of size and nutritive value a from fast growth rate of chicks and desired taste of both meat and eggs. However, majority indicated that if used on small chicks (≤ 2 weeks old), it affects performance which was evidenced from the mortality rate is very high. This calls for the need to ascertain on nutritive value of various termite species as well as the microbial load since quality of feed has direct impact to poultry and human.

From survey, it was observed that method, time and materials for collecting and harvesting of termite differ across caste and species. For alates light trapping is mainly used with trapping bait strategically placed at time of their emergence which also varies per species. The community used different source of light based on social economic status at night ranging from electric bulbs, bright torch, hurricane lambs to reflectors to harvest alates of *Macrotermes bellicosus* that emerge from mid night to 3.00 am. Natural sunlight is used to harvest *Macrotermes sublyhanus* that emerge at different time of the day thus; 12:00 pm to 2. pm; 4:00 pm 5:00 pm; and 5:00 pm to 6:00 pm respectively where unidirectional light is provided with a pit trap at strategically positioned place. While for soldiers, there are two main methods. The mound excavation method that is proceeded by hand picking of soldiers and workers as described by [6] and baiting method which involve the underground and above ground harvesting techniques. It was observed that farmers prefer the baiting method unlike the excavation method which depends on availability of the mound alone and that the destruction of the termite nests and the entire colony makes it not effective and sustainable method as further observed in Burkina Faso [6]. For trapping method, dry wood of specific tree species were used as bait and in order of preference, tea was most preferred by respondent (30%) followed with maize stock (20%) rattle weed (10%) cow dung (10%) dry eucalyptus bark (5%) and others (5%). On choice of material the use of tea farmers reported of high yields and also it enabled recycling and reusability of the same material upon aeration for more than thrice. Maize stock gave the second highest yields but availability of the stalks is seasonal and that the material can only be used once. Couch grass similarly gave high yield but the community raised issue of availability in terms of quantities and inability to cultivate couch grass for use as harvesting material. On harvesting material application, was noted that each material could be used singly or in combination, but the yields increased upon slight addition of cow dung. The aspect of cow dung and organic material further points to study in Burkina Faso [6]. Knowledge of preference status is key in effective baiting since the response of termite species to bait depends on quality of wood in terms of moisture content, hardness,

DOI: http://dx.doi.org/10.36956/njas.v4i1.424

presence and absence of resins and lignin [9].

The choice of reported termite harvesting materials that consisted of plants of different tree species and organic compound points to cellulose, a compound that is most preferred by termites as informed by premise that, termites are detritivores organisms that mostly feed on dead plants at any level of decomposition [9]. They rely on symbiotic protozoa and other microbes in their hind gut which enhance fibre breakdown in cellulose. The choice of harvesting material by the community which from the highly ranked, dry tea wood (30%) to the least dry eucalyptus back of (5%) as feed material conform with previous studies on termites feeding habit on wood. In addition different plant species produce various secondary metabolite that attract insects in wood material [10]

On trapping method, for both underground and above method, the bait materials were placed at foraging site characterised by presence of gallaries, openings and channels. For above ground method, the harvesting materials are tightly compacted together in a spindle shaped structure "Rifumbo" and firmly supported on ground by pegs followed with covering with twigs or polythene bag to mimic the natural habitat and prevent entry of water. Whereas for underground, a shallow hall measuring standard holes of 48 cm long, 15 cm wide and 10 cm deep were used throughout the harvesting process. The holes were filled with harvested material tightly compacted, sprinkled with cow dung then covered with water proof material before adding a thin layer of soil. For both cases harvesting was done the following day early in the morning by emptying the spindle structure together with termites in a collection container or by uncovering the water proof material and scoping the termites into a collection container based on method. The community prefers morning harvesting when termites are still foraging since high yields were realised when harvesting was done before 8 am. Extreme temperatures triggers the termites to migrate back into the subterranean [6]. This conforms to their behaviour of preferring warmth, moist and availability food [11]. For both methods, yields were directly dependent on distance from one whole/spindle to the next and from mound to baiting site. Despite the termite preference of couch grass, the material was soft rare and subject to depletion before morning harvesting. Termites are always attracted to food and upon its completion they move back into their nest [6]. It was hence recommendable to use harder but preferred in correct quantities for effective yield or mixture for maximum attraction and retention since yield were dependant on. In addition to use of wood, it was observed that the community sprinkled cow dung as an attractant in which study in Burkina Faso had embraced on the placing of other organic compounds and cow dung in a pot to attract termites [6]. The recommended spacing of baiting material was further proposed to contribute to yields. The community proposed on least the use of 10 m for above method when using the spindle structure and inter hole spacing of 5 m apart for desired yields.

5. Conclusions

The five edible subterranean termites found and highly utilised as food and feed in western part of Western Kenya are *Macrotemes bellicosus*, *Macrotermes sublyhanus*, *Pseudocanthotermes millitaris Coptotermes Millitaris Pseudocanthotermes spiniger Macrotermes subhyalinus.*

In addition, there is no specific distinct habitat for termites found in the region. However, the key distinguishing feature per species is presence of either mound, galleries, mud walls and tunnels. The five species are preferred for use as feed or food based on taste, effect to birds and mortality to young chicks. Based on above findings, more research should be done to determine:

√ The nutritive value of existing termite species

√ best mode of utilisation and inclusion levels for better performance

√ ascertain the biosafety of their use as food and feed

Lastly termites harvesting technique can effectively be enhanced through identification of suitable metabolites that are mainly attractant for synthesis of artificial pheromone that will assist in baiting.

Acknowledgement

The study was funded by World Bank funded under The Africa Center of Excellence in Sustainable Use of Insects as Food and Feeds (INSEFOODS) at Jaramogi Oginga Odinga University of Science and Technology (JOOUST), Kenya.

References

[1] Kinyuru, J.N., Mogendi, J.B., Riwa, C.A., Ndung'u, N.W., 2015. Edible insects-A novel source of essential nutrients for human diet: Learning from traditional knowledge. Anim Front. 5(2), 14-9.

[2] Obiero, K., Meulenbroek, P., Drexler, S., Dagne, A., Akoll, P., Odong, R., et al., 2019. The contribution of fish to food and nutrition security in Eastern Africa: Emerging trends and future outlooks. Sustain. 11(6), 1-15.

[3] Amobi, M.I., Ebenebe, C.I., 2018. Quality of the carcass and organs of chicken fed with two different insects meals. J Insects as Food Feed. 4(4), 269-74.

 DOI: http://dx.doi.org/10.36956/njas.v4i1.424

[4] Affedzie-obresi, S., March 2019. Use of Termites by Farmers as Poultry Feed in Ghana.

[5] Sankara, F., Pousga, S., Dao, N.C.A., Gbemavo, D.S.J.C., Clottey, V.A., Coulibaly, K., et al, 2018. Indigenous knowledge and potential of termites as poultry feed in Burkina Faso Abstract. 1(1), 1-8.

[6] Dao, A.N.C., Sankara, F., Pousga, S., Coulibaly, K., Nacoulma, J.P., Ouedraogo, S., et al., 2020. Traditional methods of harvesting termites used as poultry feed in Burkina Faso. Int J Trop Insect Sci. 40(1), 109-18.

[7] Vasileiou, K., Barnett, J., Thorpe, S., Young, T., 2018. Characterising and justifying sample size sufficiency in interview-based studies: Systematic analysis of qualitative health research over a 15-year period. BMC Med Res Methodol. 18(1).

[8] Lewis, V.R., Sutherland, A.M., Haverty, M.I., 2014. Subterranean and other termites. Pest Notes. (7415), 6.

[9] Sell-kubiak, E., Wimmers, K., Szwaczkowski, T., February 2018. Review of strategies to improve feed efficiency and reduce environmental footprint in poultry Measures of feed efficiency traits and their heritability.

[10] Beran, F., Köllner, T.G., Gershenzon, J., Tholl, D., 2019. Chemical convergence between plants and insects: biosynthetic origins and functions of common secondary metabolites. New Phytol. 223(1), 52-67.

[11] Sekhar, C., Vidhyavathi, A., April 2018. Termites book. pp. 1-80.

DOI: http://dx.doi.org/10.36956/njas.v4i1.424

NASS Journal of Agricultural Sciences
http://ojs.nassg.org/index.php/NJAS

ARTICLE

Assessment of the Impact of Environment Protection in Rwanda: A Case Study of Rugezi Marshland

Ntabakirabose Gaspard[1*] Harold Ogwal[2] Jean Baptiste Habinshuti[3] Musoni Protais[4] Jeanne Pauline Munganyinka[3] David Mwehia Mburu[5] Maniriho Festus[6]

1. Ministry of Agriculture and Animal Resources, Kigali, Rwanda
2. Department of Biological and Environmental Sciences, School of Natural and Applied Sciences, Kampala International University, Kampala, Uganda
3. Department of Materials Science and Engineering, African University of Science and Technology, Abuja, Nigeria
4. Musanze District, Ministry of Local Government, Kigali, Rwanda
5. Department of Land Resources Planning and Management, College of Agriculture & Natural Resources, Jomo Kenyatta University of Agriculture and Technology (JKUAT), Nairobi, Kenya
6. College of Agriculture, Animal Sciences and Veterinary Medicine (UR-CAVM), University of Rwanda, Kigali, Rwanda

ARTICLE INFO

Article history
Received: 14 December 2021
Accepted: 13 January 2022
Published Online: 20 January 2022

Keywords:
Assessment
Impact
Environment protection
Rugezi Marshland

ABSTRACT

Environmental protection is one of the most important measures to achieve the long run and sustainability of living organisms in the world. The study was conducted in Burera and Gicumbi districts with the main aim of assessing the impact of environment protection in Rwanda. A case study of Rugezi Marchland. Data were collected using a structured questionnaire and analyzed using SPSS statistical software version 20 and STATA statistical software vision 13. Off-farm income, occupation, educational level, age, and farm size, showed a positive relationship with Rugezi marchland protection. Variables such as value of product distance to Rugezi marchland, gender, and family size had a negative influence on Rugezi marchland protection. The study also indicated that factors such as water management, increase of grass species, increase of wild animals and birds, modern house construction, zero grazing keeping revealing a positive relationship with Rugezi marchland protection. Two most serious problems encountered are the lack of occupation and low level of education.

1. Introduction

Rwanda is one of the most overpopulated countries in Africa and in the world. It causes the farming land to become insufficient while this land is expected to produce a good harvest to feed this mass of population. The consequence is that the population farm all possible land, marshlands included and those activities are done in a high vagrancy where the environment is damaged. It is currently suffering from tremendous pressure on agricultural land due to the rapid demographic growth and the limited availability of productive land where 90% of the working population in Rwanda is employed in the agriculture sector [1].

**Corresponding Author:*
Ntabakirabose Gaspard,
Ministry of Agriculture and Animal Resources, Kigali, Rwanda;
Email: gmutago@gmail.com

 DOI: http://dx.doi.org/10.36956/njas.v4i1.464

Marshlands are important elements of Rwanda's watershed systems. A great deal of the hydrological and water resources problems currently experienced in Rwanda are the resultant effects of wetland degradation in the country. The challenges posed by the degradation can better be understood and better appreciated when viewed against the backdrop of the benefits derivable from the wetlands. The total area of marshland in Rwanda is approximately 278,000 ha of which, in 2009, 53% was used for cultivation. This accounts for 12% of the total cultivated land in the country [2]. Day to day men and women of study area use these above grasses from Rugezi marshland for making different materials in hand crafts that are economically resources of income for people of the region. Its restoration reopened a corridor for migratory birds and fishes, and provides good conditions for many plants and animal species, particularly the endangered and threatened species [2].

Wetlands are one of the world's most productive ecosystems and they provide valuable goods and services for humankind. Development projects often destroy wetland functions and degrade the true value of wetlands, resulting in unsustainable development with gains that are only short-term [3].

They are sinks into which surface waters or groundwater flows from a surrounding catchment. Within landscapes, they are natural harvesters of rainwater and, by definition; they are sites where water occurs at or close to the ground surface [4]. On the other hand, in their study of the relationship between wetlands and urban growth in Bindura, Zimbabwe define them as lands where saturation with water is the dominant factor determining the nature of the soil development, types of soil development and the types of plant and animal community living in the soil and on its surface, and generally includes swamps, marshes, bogs and similar areas [5].

The United States Environmental Protection Agency defines wetlands as land areas covered with water or where water is present at or near the soil surface all year or varying periods of the year [6].

The current use and management of water and wetland resources is dominated by the construction of large dams to store much of the available water for hydropower, irrigation and urban water supply and fish ponds. This practice, which serves to exacerbate the climate variability and change impacts, has often left too little for maintaining the traditional wetland function downstream and caused significant stream flow regime change in most of the major wetlands in Rwanda. For many years ago, different wetlands including Rugezi were not well-protected and dried due to different factors including human being activities particularly crop farming [7]. In 2001, thanks to African Development Bank (ADB) funds, the MINAGRI developed a master plan of marshlands development, soil conservation and watersheds protection. This scheme led to wetland classification in accordance with their hydrological aspects, their level of degradation and recommended the conservation of highland wetlands as integral part in water resources management [7].

Rugezi marshland is located in the Northern and bounded by two districts namely Burara and Gicumbi. It is surrounded by the higher mountains of the country that provide permanent freshwater. Due to its value on the international level, this marsh has been protected under the Ramsar Convention. A few years ago, this marshland got dried because of intensive crop farming; the consequences had affected all Rwandans, water from lakes of Burera and Ruhondo had decreased, thus causing a lack of hydropower in the whole country [8].

The Rugezi marshland is a protected area, covering 6,735 ha and one of headwaters of the Nile River. At 2,100 m, the marshland is a high altitude peat bog. The wetland functions as a regulating basin to moderate the flows inflows and outflows. The marsh controls, preserves, and filters water resources, which flow into the downstream lakes of Bulera and Ruhondo [9].

It is also an important bird area recognized by the Bird Life International in 2001. The zone of important bird area is identified as 8,500 ha. The floral species found in the marsh include *Miscanthidium violaceum*, *Cyperus latifolius* and papyrus *C. papyrus* species. Of the 43 species of birds in the swamp and its surrounding afrotropical highlands biome, the globally threatened species are *Bradypterus graueri* (Grauer's swamp-warbler), *Laniarius mufumbiri* (papyrus gonolek*), Calamonastides gracilirostris* (papyrus yellow warbler) and *Balearica regulorum* (Grey crowned crane). The species of least concern are *Cisticola carruthersi* (Carruthers's cisticola), *Bradypterus carpalis* (white-winged scrub-warbler), *Onychognathus tenuirostris* (slender-billed starling), *Ploceus baglafecht* (baglafecht weaver), *Nesocharis ansorgei* (white-collared oliveback), *Crithagra frontalis* (yellow-browed citril), *Crithagra koliensis* (papyrus canary) and *Crithagra burtoni* (thick-billed seedeater) [9].

Environmental issues related to Rugezi Marsh include of agricultural reclamation and generating hydropower from water supply systems. Its success as water balancing of the resources has been damaged in recent years due to high anthropogenic pressure and as well due to the development specific project of agricultural reclamation and drainage of the marsh [9].

DOI: http://dx.doi.org/10.36956/njas.v4i1.464

The degradation has complicated water resources management in Lakes Bulera and Ruhondo catchments and the cost to replace or rehabilitate the hydrological functions of Rugezi Marsh is putting a heavy burden to the government, local authorities and international organizations.

Rwanda is naturally endowed with abundant groundwater resources, but the water supply situation in some area of the country for various uses remains far below expectation [10]. Marshlands are one of the world's most important resources because of the many environmental and socioeconomic benefits they provide. Different products from Rugezi marshland are grasses resources for manure, wildlife resources, fisheries, Medicinal Plant, Wild honey, forage resources, mulch resources, agricultural resources, and water supply directly for home use (cooking, construction, clothes washing, and irrigation) and indirectly for electricity generation. Different functions of Rugezi marshland protection are also groundwater recharge, flood control/regulation shoreline stabilization /erosion control, sediment or toxicant retention, nutrient retention, biomass export, Fertility, Water conservation, storm protection/windbreak, microclimate stabilisation, water transport, recreation, and tourism. However, the paradox is that they are still being degraded at a rapid rate worldwide despite their relative importance to the general ecosystem [11].

Wetlands ecosystems play a key role in water quality and quantity management, and vice versa, the water resources quantity and quality provide key services to ecosystem health. The water quality and quantity that they provide maintains the habitat for animal and plant biodiversity [12].

There was ample evidence that rural households used environmental resources quite extensively quantitatively proved environmental resources contribution to household's income [13]. The main functions of wetlands such as flood control, groundwater recharge, coastal protection, sediment traps, atmospheric equilibrium and waste treatments as well as biological productivity, which provide nurseries for aquatic life and habitat for upland mammals such as deer, raccoons and Salamande. All over the world, wetlands are used as recreational sites in various ways boating, picnics, yachting, fishing, boat regatta [14].

In a latter study of the economic consequences of wetland degradation for local populations in Africa, acknowledge the importance of wetlands for the sustenance of rural dwellers in Africa [15].

Discussions on the services these ones provided are numerous [16]. Considerable research has been carried out on specific roles they play in the livelihoods of local residents and local environmental interactions [17]. Rugezi Marshland is one of the wetlands found in Rwanda, which is located in the Northern Province in two districts namely Burera and Gicumbi. This marshland has around 7000 ha and it is surrounded by the higher mountains of the country that provide permanent freshwater [18]. It offers both directly and indirectly many products used in different functions important in the livelihoods of local people.

The marshland protection is also the most important ecosystem service and forms a large potential for recreation and ecotourism. In Rwanda, it supports the livelihoods of many poor people through agriculture for both food and income [19]. The protection of Rugezi marshland will increase the *Clarias liocephalus Haplochromis (*Ishonz*i)* in water and Sitatunga (*Tragelaphus Speke:*Inzobe*)* that have in past have reduced by hunters.

Various studies on Rugezi marshland did not show the importance of marshland protection. It is in this regards that this study will focus on an economic analysis of the impact of wetlands protection in Rwanda. A case study of Rugezi marshland in located in Burera and Gicumbi districts. Specific objectives are to identify the economic factors influencing Rugezi marshland protection in the study area and to determine the social economic impact of Rugezi marshland protection.

2. Material and Methods

2.1 Description of Study Area

This study was conducted in two districts namely Burera and Gicumbi of the Northern Province. The Rugezi Marshland located between 1° 21'30''and 1°36'11''of south latitude and 29°49'59''and 29°59'50'' east longitude. It covers an area of 6,735 ha. The annual mean rainfall on the hillsides is 1200 mm/year at 'Rwerere-Colline' site whereas at the marsh surface it is 1050mm/year [20].

2.2 Sampling Design and Sample Size

A multistage sampling technique was employed in this study. The first stage was the purposive selection of two districts namely Burera and Gicumbi where the Rugezi wetland located. The second stage was the sample random sampling of seven sectors such as Gatebe, Kivuye, Gutaro, Cyeru, Rwere, Ruhunde and Miyove selected based on their proximity to Rugezi wetland. Twenty (20) respondents were selected from each of the seven sectors making one hundred and forty (140) sample size

 DOI: http://dx.doi.org/10.36956/njas.v4i1.464

of targeted respondents living in the proximity of this marshland.

2.3 Data Collection

Data were collected from seven sectors by using a structured questionnaire. Field observation, focus group discussion, formal and informal interviews were used for collecting data used in this study.

2.4 Data and Analysis

The logit regression model was chosen for this study because it is computationally simpler. It gives the effect of the various factors on Rugezi Marshland protection and Social economic impact of Rugezi marshland protection in the study area. Descriptive analysis was done using SPSS version 20 and regression analysis using STATA version 13.

3. Results and Discussions

3.1 Socio-Economic Characteristics of Sampled Respondents

Table 1 shows that the male population as about (76)54.293% of them dominated in the protection of Rugezi marshland. This is actually indicated by female who use different grasses such as (*Cyperus latifolius, Joncus sp, Typha, Papyrus sp, Miscanthus Violaceus*) in hand craft that generate household's income. In the other hands, the majority of women use same grasses in agriculture as mulch and fodder for livestock keeping more than men do and fuel for energy for cooking. Generally, these activities degrade wetland more than to protect it. This is sometimes because women do not have other occupation than cultivation and handcraft making. The results indicated that the majority of the study are in the range between four and seven persons per household with 69 (49.28%). This shows that due to the lack of other occupation in region as, family size increase the protection of wetland reduce because most of members of family will go cuts some species of grasses for doing hand craft for women and for men they go to fish some specie like *Clarias liocephalus Haplochromis* (Ishonzi) and hunt Sitatunga (*Tragelaphus Speke:* Inzobe*)* if any. These two actions are the main degrading Rugezi marshland rather that protecting it.

In this study, the results pertaining to the age of respondents are presented in Table 1. The findings revealed that the most of respondents are in range between thirty-one and fourth years with 60 (42.86%). The three groups indicated that the majority of respondents were in the active labor force. This implies that as these three categories have other occupation should be held in the development of the study area but in contrast the lack of other occupation these groups should degrade the wetland. Especially young men are the most to fish some specie like *Clarias liocephalus Haplochromis* (Ishonzi) whether there is no other option.

It has been found that about 63 (45%) of respondents were respondents without formal education followed by primary with 45 (32. 14%) and the third class was secondary school with 15 (10.71%). The fourth place was occupied by vocation with 10 (7.15%) where the last class was for university. Considering the results, the sum of respondents educated presented 77 (55%) of the study population. This means that the Rugezi marshland will be more protected when the number of respondents without formal education reduce at lowest level. This is because as the number of educated population increases the choice for other occupation also increase which reduce the degradation of natural resources and receptive to innovations as the number of educated increase. The study was supported by the study of Botlhoko G. J and Oladele O. I. [21], indicated that literate farmers are likely to adopt innovation than respondents without formal education farmers, hence, their productivity increases and greater farms' returns. For this reason, the protection of Rugezi marshland will be more efficiency as the number of educated people increase as more as possible.

Majority 50% of the respondents had experience in agriculture activities between eleven and twenty years with 55 (39.29%) followed by the group of the 21years and above with 46 (32.86%) and finally the range between one and ten years with 39 (27.85%). It was also implies that farmers will increase output given the number of years they have spent farming; they are expected to have gained enough knowledge. [22] noted that farmers sometimes count more on their experiences than educational attainment in order to increase their productivity. With this reason given the farmers in study area should not give value on protection rather than cuts grasses for making manure and mulches for agriculture as good agricultural practice that facilitate maximization of productivity.

The findings revealed that respondents have an average farm size less or equal to 0.5 ha with 78 (55.71%) followed by the range between 0.6-0.8 ha with 39 (27.86%.). The results showed that respondents of the lowest class was that of 1ha and above with 6 (4.29%). It implies that in one hand respondent with big land should not degrade the wetland because they can be occupied by agriculture activities but in other hand, it should degrade

DOI: http://dx.doi.org/10.36956/njas.v4i1.464

Rugezi marshland due to the need of grasses for manure and mulches for their big farms.

The results in Table 1 showed that the majority of married respondents represent 63 (45%) followed by the widower with 30 (21.43 %.). The third place was for single respondents with 25 (17.86%) and the last one was for divorced with 22 (15.71%). It implies that an effort for Rugezi marshland protection should more made by married people, widower, single, and divorced respectively. This implies that one married people protect marshland than other classes as indicated by the findings pertaining to marital status in Table 1.

Table 1. Socio-Economic Characteristics of Sampled respondents.

	Frequency	%
Gender		
Male	76	54.29
Female	64	45.71
Total	140	100
Family/household size		
1-3	30	21.44
4-7	69	49.28
8 and above	41	29.28
Total	140	100
Fam size(ha)		
≤ 0.5	78	55.71
0.6-0.8	39	27.86
0.9-1	17	12.14
≥ 1	6	4.29
Total	140	100
Age		
≤ 30	44	31.43
31-40	60	42.86
41-50	21	15
≥ 51	15	10.71
Total	140	100
Education level		
Respondents Without Formal Education	63	45
Primary	45	32.14
Secondary school	15	10.71
Vocation	10	7.15
University	7	5
Marital status		
Single	22	15.71
Married	63	45
Divorced	25	17.86
Widower	30	21.43
Experience		
1-10	39	32.86
11-20	55	39.29
21 and above	46	27.85
Total	140	100

Table 2. Main different species of grasses in marshland used by people in study area.

No	English name	Local Name (Kinyarwanda)	Use by local community
1	*Papyrus sp*	Rufunzo	Handcraft(ceiling,fence,chair, basket), fuel
2	*Typha angustifolia*	Umuberanya	Hand craft(mat, rope), fodder
3	*Cyperus latifolius*	Urukangaga	Handcraft(mat),fodder, compost, mulch, fuel
4	*Joncus sp*	Ubusuna/ ubuyundo	Handcraft(mat, rope),fodder, compost
5	*Miscanthus Violaceus*	Uruguhu	Roof cover, fodder, mulch, stakes, fuel
6	*Sphagnum*	Ubupfumfu	Compost, mulch, fuel
7	*Vaccinum Stanley*	Inturunyunyu	Fodder, compost
8	*Shrubs*	Amayayu	Fuel, brooms
9	*Cyperus dendatus*	Umurago	Fodder, baya salt for cattle
10		Ubwina	Hand craft(mat, rope), fodder

3.2 Factors Influencing Rugezi Marshland Protection in the Study Area

The results indicated that five explanatory variables were positively related to the protection of Rugezi marshland and four variables were negatively related to protection of Rugezi marshland. The R^2 of 0.6958 implied that 69.58% of variation in the Rugezi marshland protection in the area is explained by the independent variables shown in the table below.

Table 3. Factors influencing Rugezi marshland protection in the study area.

Variables	Coefficient	Standard Errors	P- value
Farm size	0.011	0.013	0.075
Family size	-1.541	0.889	0.053
Age	0.026	0.032	0.067
Educational level	0.036	0.013	0.007
Value of product	-0.054	0.378	0.000
Gender	-1.535	2.343	0.004
Experience in agriculture	-1.968	0.994	0.086
Distance to Rugezi	-0.056	0.304	0.000
Occupation	0.037	6.326	0.000
Off-farm Income	0.044	0.052	0.000
Intercept	1.283	0.271	0.001
Number of obs =140 F(10, 129) = 58.44			
Prob > F=0.0000 R-squared = 0.6958			

The results of the regression model indicated that five factors such as off-farm income, occupation, educational level, age, and farm size, showed a positive relationship with Rugezi marshland protection where three factors namely as off-farm income, occupation, educational level were statistically significant at 1% level. This

 DOI: http://dx.doi.org/10.36956/njas.v4i1.464

implies that a 1% increment in the very good occupations than agriculture should increase the Rugezi marshland protection by 3.7%. While a 1%, increase in off-farm income should increase this marshland protection by 4.4%. For the same study 1 % increase in education level, the Rugezi marshland should be protected by 3.6%.

The study results also revealed that there was a negative and significant relationship between Rugezi marshland protection and four independent variables Value of product, distance to Rugezi marshland, gender, and family size. Three of these four were statistically significant at ($p< 0.01$). For example, the study indicated that 1 % increase in value of products (mat, basket, rope, hat, chair, desk and ceiling) made from the grass of wetland; the degradation should be increase by 5.4% while a 1% in reduction of distance to Rugezi marshland the degradation should be increase by 5.6% by the easy transportation of grasses for handcraft made, fuel, mulches, fodders for livestock feeding, manure composting, fishing of *Clarias liocephalus (Haplochromis* for young men and men and hunting of some wild animals and birds if any. Therefore, if the distance to such facilities is large, the likelihood of using Rugezi marshland products for sales may be less.

3.3 Social Economic Impact of Rugezi Marshland Protection in the Study Area

The results indicated that six explanatory variables were positively related to the protection of Rugezi marshland and four variables were negatively related to protection of Rugezi marshland. The R^2 of 0.7145 implied that 71.45% of variation in the Rugezi marshland protection in the area is explained by the independent variables shown in the table below.

Table 4. Social economic impact of Rugezi marshland protection in the study area.

Variables	Coefficient	Standard Errors	P- value
Constant	1.241	0.639	0.000
Medical insurance	-0.036	0.101	0.544
Payment of school fees	-0.042	0.236	0.912
Zero grazing keeping	0.028	0.089	0.000
Modern house construction	0.248	0.108	0.000
Transport facilities	-0.06	0.096	0.018
Buy of electricity	-0.089	0.148	0.065
Cost of land	-0.059	-0.118	0.048
Increase of wild animals and birds	0.081	0.225	0.037
Increase of grass species	0.074	0.391	0.001
Water management	0.039	0.75	0.006
Ntaruka electricity protection	0.045	1.067	0.000
Number of obs =140 F(11, 128)= 47.39			
Prob > F= 0.0000 R-squared = 0.7145			

The results of the regression model indicated that five factors such as water management, increase of grass species, increase of wild animals and birds, modern house construction, zero grazing keeping revealed a positive and economic impact relationship with Rugezi marshland protection while five factors namely cost of land, buy of electricity, transport facilities, payment of school fees, medical insurance were negatively indicated economic impact with Rugezi marshland protection. This implies that a unit increment in Rugezi marshland protection should increase the water management by 3.9 unit in both quality and volume. Whether Rugezi marshland protection is increased by 1%, then 7.4% should increase different species of grasses both in goodness and in life expectancy. This is a socio-economic impact for population through the ecosystem control and oxygen supply for respiration. The results indicated also that an increase in 1% of Rugezi marshland protection, the wild animals and birds should be increased by 8.1%. This suggests that an increase in Rugezi marshland protection should excellently satisfy tourist demand in study area. However, the increase in tourists' satisfaction directly increase income generation improving livelihood of population. The happiness of tourist facilitates Government to create new jobs for both educated and non-educated people. The results also indicated that 1% increase in Rugezi marshland protection should increase Ntaruka hydroelectricity power stability by 4.5%. Globally, the impact whether Rugezi marshland satisfy the electricity power users very good. Therefore, the protection enhance, the supply of electricity from Ntaruka hydroelectricity power and Mukungwa should be stable as long as possible and well distributed across the whole country very good.

4. Conclusions and Recommendations

This study reveals that off-farm income, occupation, educational level, age, and farm size, showed a positive relationship with Rugezi marshland protection. The study indicated that six factors such as water management, increase of grass species, increase of wild animals and birds, modern house construction, zero grazing keeping, Ntaruka hydroelectricity power revealed had positive and economic impact relationship with Rugezi marshland protection. As recommendation with Rugezi marshland protection government and police makers should make tangible effort in education, jobs creation towards the implementation of policies that enhances Rugezi marshland protection. This will biologically and economically help in water management, increase grass species, increase number and lifespan of wild animals and birds that are the main source of tourism demand in study area.

DOI: http://dx.doi.org/10.36956/njas.v4i1.464

References

[1] Nwaru, J.C., 2004. Rural Credit Market and Arable Crop Production in Imo State of Nigeria. Unpublished Ph.D Dissertation, Michael Okpara University of Agriculture, Umudike, Nigeria.

[2] REMA and MINIRENA, 2008. Regreening Thousand Hills in Rwanda's Wetlands towards 2020 vision.

[3] Kadziya, L., Chikosha, F., 2013. Wetlands and Urban Growth in Bindura, Zimbabwe: Greener Journal of Environmental Management and Public Safety. 2(6), 195-196.

[4] MINAGRI, 2001. Schéma directeur d'aménagement des marais. De protection des bassins versants et de la conservation des sols. Rapport global définitif. HYDROPLAN ingénieurs Gesellschaft mbH. Kigali. 38.

[5] McCartney, M.P., Rebelo, L.M., 2010. Senaratna Sellamuttu, S.; de Silva, S. Wetlands, Agriculture and Poverty Reduction Colombo, Sri Lanka: International Water Management Institute (IWMI). 39.

[6] www.bureradistrict.gov.rw

[7] MINALOC, 2004. Mission d'étude de conservation et de gestion intégrée du Marais de Rugezi. Rapport provisoire. Helpage-Rwanda, Kigali. 112.

[8] Rukundo, E., Liu, S., Dong, Y., Rutebuka, E., Asamoah, E.F., Xu, J., Wu, X., 2018. Spatio-temporal dynamics of critical ecosystem services in response to agricultural expansion in Rwanda, East Africa. Ecological Indicators. 89, 696-705.

[9] Schuyt, K.D., 2005. Economic Consequences of Wetland Degradation for Local Populations in Africa. 1-14.

[10] Nabahungu, Visser, S., 2013. Farmers 'knowledge and perception of agricultural wetland management in Rwanda. Land Degradation & Development. 24(4), 363-374.

[11] MINITERE, 2003. Etudes relatives' à la protection intégrée et conservation des ressources naturelles des zones humides critiques du Rwanda. Évaluation de la diversité biologique des zones humides, Experco des Grands Lacs. Kigali. 78.

[12] USEPA, 2009. What are Wetlands? http://www.epa.gov./owow/wetlands/vital/what.html Retrieved August 2014 from U.S EPA.

[13] Cavendish, W., 2000. Empirical regularities in the poverty environment relationship of rural households: Evidence from Zimbabwe. World Dev. 702-715.

[14] Chidi, H.O., Erhabor, F.O., 2009. Biodiversity of wetlands and wealth creation in Niger Delta. International Journal of Development Studies. 4(3), 108 - 115.

[15] Uluocha, N.O., 2004. Implication of wetlands degradation for water resources management, Lessons from Nigeria. Geojournal. 61, 151-154.

[16] Hategekimana, S., 2005. La degradation actuelle du Marais de Rugezi: une catastrophe écologique. Mémoire de Licence, Université Nationale du Rwanda. 115.

[17] Adger, W.N., Luttrell, C., 2000. Property rights and the utilization of wetlands. Ecological Economics Agrawal. 35, 75-89.

[18] Nwaru, J.C., 2004. Rural Credit Market and Arable Crop Production in Imo State of Nigeria. Unpublished Ph.D Dissertation, Michael Okpara University of Agriculture, Umudike, Nigeria.

[19] NISR, 2007. EICV Poverty Analysis for Rwanda's Economic Development and Poverty Reduction Strategy. Final Report. National Institute of Statistics of Rwanda (NISR), Kigali.

[20] Hollis, G.E., 1990. Environmentalimpacts of development on wetlands in arid and semi - aridlands. HydrologicalSciences Journal. 35, 411-28.

[21] Botlhoko, G.J., Oladele, O.I, 2017. Factors Affecting Farmers Participation in Agricultural Projects in Ngaka Modiri Molema District North West Province, South Africa. Journal of Human Ecology. 201-206.

[22] REMA, 2009. Rwanda State of Environment and Outlook Report. Kigali: Rwanda Environnent Management Authority. 245.

 DOI: http://dx.doi.org/10.36956/njas.v4i1.464

NASS Journal of Agricultural Sciences
http://ojs.nassg.org/index.php/NJAS

ARTICLE

Development and Evaluation of Self-propelled Cabbage/Cauliflower Harvester

Jagvir Dixit* **Naieam Jan Rawat**

Division of Farm Machinery and Power Engineering, College of Agricultural Engineering & Technology, SKUAST-K, Srinagar (J&K), India

ARTICLE INFO

Article history
Received: 25 December 2021
Accepted: 24 January 2022
Published Online: 27 January 2022

Keywords:
Self-propelled
Harvester
Cabbage/cauliflower
Field capacity
Field efficiency
Untrimmed percentage

ABSTRACT

In the present study, self-propelled cabbage/cauliflower harvester was designed, developed and evaluated. The machine consisted of different components like engine, frame, shearing (cutting) unit and power transmission unit. The power transmission unit consisted of main clutch, shearing blade operating clutch, belt drive unit, chain and sprocket drive, universal joint and cutter blade assembly. The main working principle of harvester is based on shearing of crop stem against high-speed rotating blade. The power from the engine is transmitted by belt-pulley drive unit to transmission shaft on which chain and sprocket is mounted on one side and then power is transmitted to shearing blade coupling with the help of a stationary pulley and fixed socket. Average mean head diameter of the selected cabbage and cauliflower was 89.5 ± 15.24 mm and 107.5 ± 15.24 mm, respectively. Average mean stem (plant) diameter of the selected cabbage and cauliflower was 18 ± 4.85 mm and 21.5 ± 3.08 mm, respectively. The shearing force increased with increase in diameter of stem. The optimum performance of the machine was achieved when it was operated at 1.5 km/h forward speed and the shearing blade moving at speed of 147 rpm. The mean field capacity for developed prototype was observed as 0.063 ha/h and 0.053 in case of cabbage and cauliflower, respectively with field efficiency of 91.97 and 90.48 %. The average head damage was negligible (0.15 %) for both the crops. The average untrimmed percentage with developed harvester was 3.2 and 3.0% in case of cabbage and cauliflower crop, respectively. The developed machine helps to increase the field capacity in cabbage/cauliflower harvesting due to 7-times more capacity and 50% cheaper compared to traditional method of cabbage/cauliflower harvesting. At the operating condition of forward speed (1.5 km/h) and shearing blade speed (147 rpm), the machine could harvest 0.5 ha of cabbage and 0.42 ha of cauliflower farm per day of 8-h. This same task would have required between 15 labour per day if entirely done manually.

1. Introduction

Agriculture plays an important role in economic development in India. India is the second largest in farm output, seventh largest in its export worldwide. India is the second largest producer of cabbage/cauliflower (*Brassica oleracea*)/ next to China in the world. Cabbage is famous for its nutritional values, medicinal effects, and

**Corresponding Author:*
Jagvir Dixit,
Division of Farm Machinery and Power Engineering, College of Agricultural Engineering & Technology, SKUAST-K, Srinagar (J&K), India;
Email: jagvirdixit@yahoo.com

DOI: http://dx.doi.org/10.36956/njas.v4i1.471

other therapeutic properties. It is consumed throughout the country by every class of people as fresh vegetable or raw as salad. Cabbage may be cheap in price but very high in protective vitamins having a very low caloric value and very rich in nutrients. The cultivated area is about 400138 ha with a production of 9039219 MT per year i.e. about 12.80% of total world production and has rank 6th among all the vegetables in India [1] but the productivity of the crop is quite low 22.6 metric tons per hectare. However, being a large area under vegetable cultivation farm practices like transplanting and harvesting are done by traditional methods such as hand picking or by use of a sickle to cut the stem and leafy portion in India. Some researchers worked on mechanical harvesting of cabbage. An one-row towed harvester operated at a speed of 0.5-1.0 mile per hour uproots the cabbage, conveys it to a circular cutting blade, separates the leaves from the heads, and delivers it to transportation vehicles [2]. [3] while conducting studies on the relationship of yields and physical properties to the mechanical harvesting of cabbage found that a fixed cutting height can be found for each field so that 2.5% of the heads will be cut too high and a varying percentage dependent upon variety and location. On the other hand, it would be very difficult to sense the proper cutting height for each head and adjust the cut to that elevation. [4] attempted to mechanize the operation by designing a mechanical harvester for the vegetable. The machine lacerates and bruises the vegetable and there by reduces its quality. Also, provision was not made to collect harvested vegetable. An empirical formulae established of unit cutting force and mechanics model for sugarcane stalk [5]. Based on high speed photography analysis, they also found that cutting speed, cutting position and forward velocity had significant effects on stubble damage. A tractor PTO operated leafy vegetable harvester for herbaceous vegetables in which the ground wheel powered the conveyor belts for transporting the harvested vegetable from the cutting unit to the storage bin [6]. Results indicated that the field capacity of the machine increased linearly with increase in knife speed and forward speed. But at high vegetable height (average of 69.60 cm), the harvesting efficiency reduced considerably due to the frame of the machine which tends to push "standing" vegetables away from the reach of the cutting unit. Cutting the cabbage root with single point clamping way could reduce the maximum and the average cutting force effectively, but may cause increase in the splitting failure [7].

The traditional methods of transplanting and harvesting require lots of skilled labour and capital, sometimes there is a shortage of labour during harvesting. The unavailability of labour, causes delay in harvesting operations which directly affects the crop production and economic returns of the farmers. Alone harvesting requires more than 50% of processing cost. There are no mechanical cabbage/cauliflower harvesters available at present in India. With cauliflowers/cabbage requiring selective picking it means that the only currently available mechanized harvesting technique is to use humans to detect the maturity, cut and trim the product and collect the product. Keeping in view of these, there was a need of mechanization in the harvesting process of cole crops like cabbages/cauliflowers.

2. Materials and Methods

Before designing of harvester, physical properties like head height, head diameter, plant diameter, length of stem, plant height and length of leaf stem, shearing (cutting) force of cabbage and cauliflower were measured using vernier caliper (Figure 1). The measurement of cutting force was done with the help of a texture analyzer in PHT lab of SKUAST-K Srinagar. The cutting force was determined at a pre-test speed of 2.00 mm/sec and post-test speed of 10 mm/s. The distance of cut was maintained at 30 mm with trigger force of 0.04903N and a load cell of 50 kg. The cutting force in cabbage and cauliflower stem was obtained by cutting stem of different diameters (Figure 2). A conceptual view (Figures 3 & 4) of the self propelled cabbage/cauliflower was prepared using Auto CAD-2016 software keeping in view of its functional requirement. An existing power weeder was used for modification and development of self propelled harvester. The rotary weeder unit was removed and a guiding wheel was fitted in the front of developed harvester.

Design of different components

The developed harvester consisted on a power source, frame, power transmission unit and cutting blade (Table 1).

Power Source

An I.C. engine of 5.5 hp (rating) with cubic capacity 255 cubic cm single stroke was used in the machine which runs on kerosene with petrol start. It was having a throttle lever on handle frame used to increase or decrease the forward speed of machine. There was a provision of 3 different speed levels low, medium and high speed.

 DOI: http://dx.doi.org/10.36956/njas.v4i1.471

Figure 1. Measurement of physical dimensions of cabbage

Figure 2. Measurement of stem cutting force using Texture Analyzer

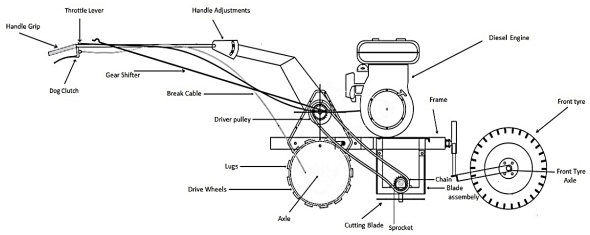


Figure 3. Conceptual view of self propelled Cabbage/ cauliflower harvester

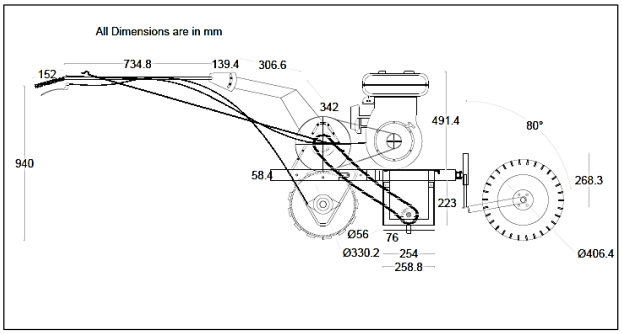


Figure 4. Back view of the developed machine

Frame

The frame was made up of mild steel angle iron of 25 mm section. It is made up of two rectangular parts of different length. The front and back part are joined with the help of welding corners of flat angle iron to form a rectangular frame of dimensions 462.8×175 mm. The frame is bolted to the angle iron support provided in the machine, so that proper cutting height is sensed from the ground level during conducting field operation. The shearing/cutting blade was fitted on a frame made of flat angle iron. The overall dimensions of frame are 462×175× 95 mm.

Power transmission unit

The power transmission unit consisted of main Clutch, cutting blade operating clutch, Belt drive unit, Chain and Sprocket Drive, Universal joint, Cutter Blade Assembly. The descriptions of the components are given below.

Main clutch: It was provided to control the forward speed of the machine as well as to control the power transmission unit i.e. used to control the whole power of the machine. The dog clutch was used as main clutch.

Cutting blade operating clutch: It was provided to engage or disengage the power from the engine to cutting blade. The engine power could be disengaged by way of cut off the belt drive power.

Belt drive unit: The power from the engine is transmitted to transmission shaft through belt-pulley

DOI: http://dx.doi.org/10.36956/njas.v4i1.471

drive. The purpose of this drive unit is to reduce the speed. The size of driver and driven pulley was taken as 275 and 100 mm. The center to center distance between these two pulleys was 350 mm through which power was transmitted to shaft. A V-belt of size B-48 was used.

Chain and Sprocket Drive: The power from the transmission shaft is transmitted to the cutting/shearing blade assembly through chain and sprocket unit. This driver sprocket consisted of 16 teeth while driven sprocket consisted of 12 teeth. A pintle chain of length 48 links 1219 mm length was used to transmit power through shaft of diameter 25 mm to cutter bar assembly i.e. (from universal joint of 200 mm to cutter blade).

Table 1. Specifications of self-propelled cabbage/ cauliflower harvester

S. No.	Description	Dimensions (mm)
1.	Power source	: I.C. engine petrol start, kerosene run 5.5 hp (rating), Displacement volume: 255 cubic cm, single stroke
2.	Frame Overall dimension (lxbxh)	: rectangular shape 462×175× 95 mm
3.	Power transmission unit	: Chain and sprocket (driver sprocket consisted of 16 teeth while driven sprocket consisted of 12 teeth) : Belt and pulley (size of driver and driven pulley was taken as 275 and 100 mm)
4	Shearing/Cutter blade Size (diameter x no of teeth), mm Material	: 250 ×80 : high carbon steel of 20 mm top
5	Angle of power transmission	30˚
6.	Chain sprocket (No. of teeth)	16
7.	Length of Pintle chain	1219

Shearing (Cutting) unit

Cutting unit was mounted on the upper part of the frame. It is made up of high carbon steel of 20 mm top and is bolted on the upper part of frame, and cutting blade of diameter 250 mm rotates at its periphery with dimensions 250 mm×80 (No. of teeth). The brush cutter shaft of diameter 20 mm is adjusted in to the coupling mounted on the upper part of frame with the help of internal threads and welding.

Working of the self-propelled mechanical cabbage/ cauliflower harvester

The main working principle of self-propelled cabbage/ cauliflower harvester is based on shearing of crop stem against high-speed rotating serrated blade. The power from the engine is transmitted by belt-pulley drive unit to transmission shaft on which chain and sprocket is mounted on one side and then power is transmitted to cutter blade coupling with the help of a stationary pulley and fixed socket. The speed at main pulley of engine was measured as 317 rpm while the speed of cutting blade was measured as 58 m/s corresponding to the machine at stationary position.

Evaluation of machine

The machine was evaluated to analyze the effect of independent parameters on individual dependent parameter by taking different levels of following independent parameters. The evaluation of self-propelled mechanical cabbage/cauliflower harvester was carried out on two different sites at Haran and Wompora villages of district Budgam during 2017-2019 (Figure 5). An area of 180 m^2 along 10 m row length each for cabbage and cauliflower was selected for field evaluation. The dependent and independent parameters are given below:

Independent Parameters	Level	Dependent parameters
Number of crops	2 levels (Cabbage, Cauliflower)	• Field capacity (ha/h) • Percentage of trimmed cabbage/ cauliflower
Shearing blade speed (km/h)	3 levels (S_1: 291, S_2: 319 S_3: 447 rpm	• Field Efficiency (%) • Damage percentage • Labour Requirement (man-h/ha)

Figure 5. An overview of harvesting of cabbage and cauliflower with developed harvester

 DOI: http://dx.doi.org/10.36956/njas.v4i1.471

Measurement of Dependent Variables

Field capacity

The field capacity of the machine was determined by using the standard formula. The time taken to harvest cabbage and cauliflower in 180 m^2 area was recorded and field capacity in ha/h was determined.

$$\text{Effective field capacity (ha/h)} = \frac{\text{Actual area covered by machine (ha)}}{\text{Effective time (h)}}$$

$$\text{Theoretical Field Capacity (ha/h)} = \frac{\text{Width (m) x speed (km/h)}}{10}$$

Field efficiency (%)

The field efficiency was determined by using following formula:

$$\text{Field efficiency (\%)} = \frac{\text{Actual field capacity (ha/h)}}{\text{Theoretical field capacity (ha/h)}} \times 100$$

Damage (%)

For calculating the damage percentage of cabbage and cauliflower total weight of damaged cabbages and cauliflower on the 30 m row length was recorded and damage percentage was determined using following formula:

$$\text{Percentage of damage} = \frac{\text{Wt. of damaged cabbage/cauliflower}}{\text{Total Wt. of cabbages/cauliflower}} \times 100$$

Labour requirement

The man hours required to harvest cabbage/cauliflower was calculated from field capacity of the machine.

$$\text{Labour requirement (man-h/ha)} = \frac{1}{\text{Effective field capacity}}$$

Percentage of trimmed cabbage

The number of total trimmed cabbage and cauliflower were recorded on the given area and then percentage of trimmed cabbage and cauliflower were determined.

$$\text{Percent of trimmed cabbage} = \frac{\text{No. of fully trimmed cabbage}}{\text{Total No. of cabbage in selected area}} \times 100$$

Percentage of un-trimmed Cabbage (%) = 100-percentage of trimmed cabbage

The observed data were analysed for significant differences between treatments using factorial design in complete randomized block design with Opstat software-1988 The experiments were planned in a Randomized completely block design having two factors one with two levels, and other with three levels. Each treatment was replicated thrice. The developed prototype was evaluated as per 18 different treatment combinations.

3. Results and Discussion

Physic-mechanical properties

The minimum and maximum values of head height, head diameter, plant diameter, length of stem, plant height and length of leaf stem of cauliflower were 95 and 134 mm, 85 and 130 mm, 85 and 75 mm, 120 and 130 mm, 330 and 400 mm, 35 and 55 mm respectively (Table 2) while the minimum and maximum values of head height, head diameter, plant diameter, length of stem, plant height and length of leaf stem of cabbage were 68 and 195 mm, 35 and 144 mm, 110 and 230 mm, 45 and 70 mm, 250 and 400 mm, 25 and 60 mm respectively (Table 3).

Table 2. Physical properties of cauliflower

Stem Diameter (mm)	Head height (mm)	Head diameter (mm)	Length of stem (mm)	Plant height (mm)	Plant (stem) diameter (mm)	Length of leaf stem (mm)
Minimum	95	85	120	330	18.5	35
Maximum	134	130	130	400	26.0	55
Mean	114.5	107.5	125	365	21.5	45
SD	16.42	15.24	15.57	28.63	3.08	7.90

Table 3. Physical properties of cabbage

Diameter (mm)	Head height (mm)	Head diameter (mm)	Length of stem (mm)	Plant height (mm)	Plant (stem) diameter (mm)	Length of leaf stem (mm)
Minimum	68.0	35.0	45.0	250	11.0	25.0
Maximum	195.0	144.0	70.0	400	23.0	60.0
Mean	131.5	89.5	57.5	325	18.0	42.5
SD	16.31	15.24	10.36	23.87	25.64	7.90

Cutting/shearing Force

It was observed that the shearing force required to shear the stem portion of cabbage and cauliflower was dependent on stem girth. The cutting force increases with the stem diameter. The depth of cut and trigger force influenced the cutting force. The lower cut percentage at high speed levels may be due to moisture/fibre ratio, fertility gradient.For all the selected cabbages and cauliflower, cutting force for selected cabbages was recorded highest (396.52N) for cabbage stem of diameter 30-40 mm. while it was recorded lowest (212.17N)) for diameter 20-25 mm and for cauliflower stem, cutting force was recorded highest (410.52N) for diameter 35-45 mm, while it was recorded lowest (185.20N) for diameter 15-25 mm (Tables 4&5).

DOI: http://dx.doi.org/10.36956/njas.v4i1.471

Table 4. Effect of stem diameter of cauliflower on cutting force (N)

Stem diameter (mm)	R1	R2	R3	Mean	S. D
35-45	406.83	410.52	378.54	398.80	17.50
25-35	312.24	205.10	378.54	288.05	22.92
15-25	185.20	198.81	223.10	202.40	19.19

Table 5. Effect of stem diameter of cabbage on cutting force (N)

Stem diameter (mm)	R1	R2	R3	Mean	S. D
35 – 40	396.52	347.74	327.38	357.21	35.53
25 – 30	302.55	295.16	288.78	295.49	50.18
20 – 25	259.95	235.49	212.17	235.87	23.89

Effect of shearing blade speed on head damage

For both the crops, the head damage was negligible while harvesting with developed harvester however, the head damage percentage increased with an increase in forward speed of the machine (Table 6). For cabbage, the minimum head damage (0.13%) was observed at shearing blade speed of 291 rpm while the maximum head damage (0.19%) was at 347 rpm. Same trend was observed for cauliflower harvesting. The average damage was 0.15% and 0.16% for cauliflower and cabbage, respectively irrespective to the shearing blade speed of the machine. The increase in head damage at higher blade speed can be attributed to the decreased resistance of stem to shear force which causes slippage of blade corresponding to the stem texture.

Table 6. Effect of shearing blade speed of harvester on head damage

A. Cabbage	R1	R2	R3	Mean
S1	0.12	0.16	0.13	0.13
S2	0.17	0.17	0.16	0.16
S3	0.18	0.20	0.21	0.19
Average	0.15	0.17	0.16	0.16
C.D (p>0.05) ± sem		0.02±0.006		
B. Cauliflower	**R1**	**R2**	**R3**	**Mean**
S1	0.10	0.14	0.13	0.12
S2	0.16	0.15	0.17	0.16
S3	0.19	0.20	0.18	0.19
Average	0.15	0.16	0.16	0.15
C.D (p>0.05) ± sem		0.03±0.01		

Percentage of un-trimmed head

The quantity of untrimmed heads decreased linearly with an increase in shearing blade speed of the harvester. For the cabbage crop, mean untrimmed head was found lowest (1.6%) at shearing blade speed of 347 rpm and highest (5.0%) at shearing blade speed of 291 rpm, respectively. Similarly for cauliflower, the mean untrimmed percentage was 2.0% and 4.0% at shearing blade speed of 347 and 291 rpm, respectively. Statistically there was a significant difference of shearing blade speed and for both the crops on untrimmed percentage (Table 7 and Figure 6). The higher un-trimmed percentage in cabbage as compared to the cauliflower was due to the bulged stem with high moisture content which resists the cutting.

Table 7. Effect of shearing blade speed on percentage of untrimmed cabbage and cauliflower

A. Cabbage	R1	R2	R3	Mean
S1	6.0	5.0	4.0	5.0
S2	3.0	2.0	4.0	3.0
S3	1.0	2.0	2.0	1.6
Average	3.33	3.0	3.33	3.2
C.D (p>0.05) ± sem		1.29±0.42		
B. Cauliflower	**R1**	**R2**	**R3**	**Mean**
S1	4.0	3.0	5.0	4.0
S2	4.0	2.0	3.0	3.0
S3	1.0	2.0	3.0	2.0
Average	3.0	2.33	3.6	3.0
C.D (p>0.05) ± sem		1.05±0.33		

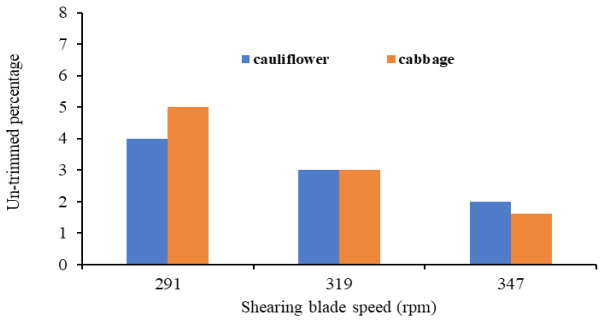


Figure 6. Mean effect of shearing blade speed on untrimmed cabbage and cauliflower head

Effect of shearing blade speed on field capacity

There was a significant effect of shearing blade speed on field capacity of the developed harvester. The field capacity of the developed harvester increased linearly with shearing blade speed for both the crops as the trimming of head stem is directly related with shearing blade speed. The mean lowest field capacity of 0.047 ha/h was observed at shearing blade speed of 292 rpm and the highest field capacity of 0.068 ha/h was observed at shearing blade speed of 347 rpm (Table 8). The mean field capacity of the harvester was significantly lower for cauliflower than cabbage. It was mainly due to hard stem of cauliflower which require more force to shear the stem (Tables 4 & 5).

DOI: http://dx.doi.org/10.36956/njas.v4i1.471

Table 8. Effect of shearing blade speed on field capacity (ha/h)

Shearing blade speed (rpm)	Field capacity(ha/h)		Mean
	C1: Cabbage	C2: Cauliflower	
S_1	0.050	0.045	**0.047**
S_2	0.065	0.052	**0.058**
S_3	0.075	0.062	**0.068**
Mean	**0.06**	**0.05**	
$CD_p \leq 0.05$			
CD for blade speed : 1.35		CD for crop type : 0.98	

C: Crop type S: shearing blade speed

S_1: 292 rpm S_2: 319 rpm S_3: 347 rpm

Effect of shearing blade speed on field efficiency

The field efficiency of the developed prototype was found highest (96.80%) for cabbage crop, at shearing blade speed of 347 rpm, while it was lowest (84.2%) at shearing blade speed of 292 rpm (Figure 7). The mean field efficiency was found highest (95.99%) at shearing blade speed of 347 rpm and lowest (87.36%) at shearing blade speed of 292 rpm. For both the crops, the field efficiency increased with increase in shearing blade speed of the cutting mechanism. The mean field efficiency was found lowest (80.21%) at shearing blade speed of 292 rpm for harvesting cauliflower and highest (96.53%) at shearing blade speed of 347 rpm. Statistically there was significant difference of field efficiency at 5% level of significance.

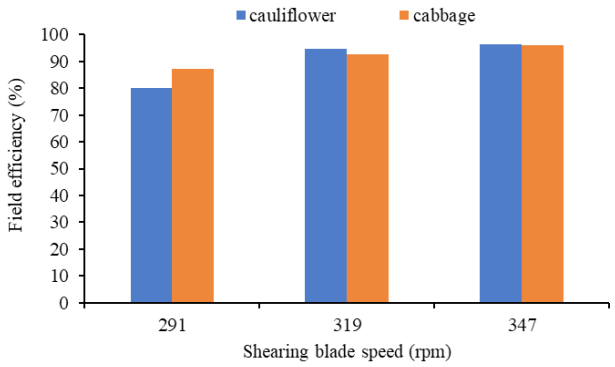


Figure 7. Effect of shearing blade speed on field efficiency of developed harvester

Effect of shearing blade speed on labour requirement

The labour requirement in man-hours per hectare was determined from field capacity. The shearing blade speed significantly affected labour requirement for harvesting of both crops and it decreased with increase in shearing blade speed of the cutting mechanism (Figure 8) as less time was required for shearing the crop stem at higher blade speed. The mean labour requirement for cauliflower was found highest (27 man-h/ha) at shearing blade speed of 292 rpm and lowest (14 man-h/ha) at shearing blade speed of 347 rpm. While as mean labour requirement for cabbage was found highest (23 man-h/ha) at shearing blade speed of 292 rpm and lowest (17 man-h/ha) at shearing blade speed of 1.5 km/h.

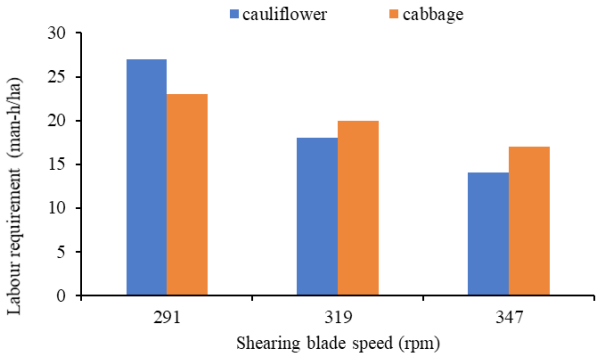


Figure 8. Effect of shearing blade speed on labour requirement

Standardization of shearing blade speed

The independent parameter viz. shearing blade speed was standardized keeping in consideration the lesser un-trimmed percentage, higher field capacity, lower head damage and lower labour requirement. The optimum response parameters obtained were 3.4%, 0.065 ha/h, 0.16% and 20 man-h/ha for cabbage at shearing blade speed of 347 rpm while for cauliflower the optimum response parameters obtained were 3%, 0.052 ha/h, 0.16% and 18 man-h/ha, for un-trimmed percentage, field capacity, head damage and labour requirement, respectively. Hence the shearing blade speed of 347 rpm was recommended for the mechanical harvesting of cabbage/cauliflower using developed harvester.

Comparison of developed harvester with traditional method of harvesting

The mean performance data of developed harvester was computed and compared with that of traditional harvesting method (Table 9). The field capacity of the developed harvester was more than 7-times than traditional harvesting of cabbage/cauliflower. The damage percentage was observed slightly higher for developed prototype (0.16%) as compared to manual method (0.05%). About 104 man-h/ha labour requirement and Rs 2809 per hectare could be saved with the use of developed harvester for harvesting of cabbage/cauliflower.

DOI: http://dx.doi.org/10.36956/njas.v4i1.471

Table 9. Comparison of manual and developed prototype method of harvesting

Parameters	Developed harvester	Traditional harvesting Method
Damage, %	0.16	0.05
Field capacity, ha/h	0.063	0.0083
Labour requirement, man-h/ha	16	120
Untrimmed Percentage	3.2	0.1
Cost of operation, Rs/ha	2791	5600

*wages= Rs. 35/h man-h for manual harvesting= 120 man-h/ha

4. Conclusions

The developed self-propelled harvester efficiently harvested the cabbage and cauliflower at forward speed of 1.5 km/h and shearing blade speed of 347 rpm. The shearing blade speed of the cutting mechanism affected the field capacity, efficiency, head damage and untrimmed head. The shearing (cutting) force increased with increase in stem diameter. The developed machine helps to increase the field capacity in cabbage/cauliflower harvesting due to 7-times more capacity and 50% cheaper compared to traditional method of cabbage/cauliflower harvesting. The developed harvester could be a viable option for harvesting of cabbage/cauliflower for small to medium sized land holdings.

References

[1] Anonymous, 2015. Directorate of Horticulture, Srinagar. Horticulture Division, Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India. (www.doh.co.in)

[2] Eiland, B., Clayton, J., 1983. Unburned and burned sugarcane harvesting in Florida. Tranaction of ASAE. 26(5), 1332-1336.

[3] Hasley, L.H., Beeman, J.F., 1996. Certain physical properties of cabbage in relation to harvest mechanization. Soc. Hort. Sci. 92, 438-445.

[4] Akande, A.L., 2004. Development of a Mechanical Harvester for Amaranthus. Unpublished M. Eng. Project Report, Fed. Univ. of Tech., Akure. pp. 5-6.

[5] Liu, Q.T., Qu, Y.G., Quing, S.L., Huang, S.X., 2007. High-speed photography analysis upon the damage process in cutting sugarcane stalk with smooth-edge blade. Transactions of CSAM. 38(10), 31-35.

[6] Du, D.D., Wang, J., Qiu, S.S., 2014. Optimization of cutting position and mode for cabbage Harvesting. Transaction of the CSAE. 30(12), 34-40.

[7] Olowojola, C.O., Faleye T., Agbetoye, L.A.S., 2011. Development and performance evaluation of a leafy vegetable harvester. International Research Journal of Agricultural Science and Soil Science. 1(7), 227-233.

 DOI: http://dx.doi.org/10.36956/njas.v4i1.471

NASS Journal of Agricultural Sciences
http://ojs.nassg.org/index.php/NJAS

ARTICLE

Awareness, Attitude and Behavioural Intention of Medium and Large Scale Poultry Producers to Poultry Waste Management Practices in Lagos State: A Principal Component Analysis

Ude, Kingsley D.[1] Osuafor, Ogonna O.[2*] Ofoha Donaldson C.[1]

1. Department of Agricultural Economics, University of Nigeria, Nsukka
2. Department of Agricultural Economics and Extension, Nnamdi Azikiwe University, P.M.B. 5025, Awka, Anambra State, Nigeria

ARTICLE INFO

Article history
Received: 27 December 2021
Accepted: 24 January 2022
Published Online: 27 January 2022

Keywords:
Awareness
Attitude
Behavioural intentions
Poultry production
Poultry waste management practices
Principal component analysis

ABSTRACT

The study analyzed awareness, attitude and behavioural intentions of medium and large scale poultry producers to poultry waste management practices in Lagos State with reference to problems of poor on-farm harness of excessive poultry waste, retrogression/unmet global environmental and economic waste management standards, exorbitant waste management charges imposed by LAWMA. Purposive and simple random sampling (using the lottery draw approach) was used in the selection of sixty (60) medium scale poultry farmers and forty (40) large scale poultry farmers, making a grand total of one hundred (100) medium and large scale poultry farmers interviewed in the study. A semi-structured questionnaire was used to collect data from the selected medium and large scale poultry farmers with the aid of a list provided by the Poultry Association of Nigeria (PAN), Lagos chapter. Principal Component Analysis (PCA) was used to analyse the data. In the principal component analysis for medium scale poultry farmers, the key component named was that LAWMA should offer special service for isolated dead bird collection (V75); and for large scale poultry farmers, the key component was that the disposal of poultry waste in an environmentally friendly way is LAWMA's duty (V76). The study recommended that the government makes provisions to offer awareness campaigns in order to improve environmental knowledge and encourage environmental enthusiasm amongst society.

1. Introduction

Waste is described as a discarded material resulting from agricultural, commercial, communal and industrial activities and it includes solids, liquids and gases (Das, 2021). Waste management involves distinct operations: storage, collection, transfer and transportation, resource recovery, recycling and final disposal [1]. Waste management (WM) has become a public good to which government agency is typically responsible [2]. Effective waste management aims at ensuring that waste does not constitute danger to health and safety of man and the environment at every stage of its handling [3].

Due to increasing volume and attendant complexity of waste generation resulting from the rapid population growth in Lagos State, managing the volume of refuse

**Corresponding Author:*
Osuafor, Ogonna O.,
Department of Agricultural Economics and Extension, Nnamdi Azikiwe University, P.M.B. 5025, Awka, Anambra State, Nigeria;
Email: oo.osuafor@unizik.edu.ng,

DOI: http://dx.doi.org/10.36956/njas.v4i1.472

generated on a daily basis has posed a major challenge to the State government, hence the need to establish an outfit for proper waste management in the State [4]. Consequently, the Lagos State Refuse Disposal Board (LSRDB) was instituted under Edict No. 9 of 1977 and was saddled with the responsibilities of environmental sanitation and domestic refuse collection and disposal in the State [5]. Between 2007 and now, various programmes and projects have been introduced, such as Lagos State Waste Management Authority (LAWMA), for improved service delivery across Lagos Metropolis in line with global best practices, while conserving the environment for future generations [6]. Lagos state is now on the verge of turning waste into income generating products, especially with the full collaboration of various stakeholders like commercial farms that generates a huge amount of the needed organic waste for the successful implementation of the project. Consequently, domestic, industrial and organic farm waste, is to become a huge revenue earner for the state and target beneficiaries [7].

In Nigeria, there is a rapid expansion of medium and large scale poultry production with the attendant effect of huge organic waste generation. According to [8] and [9], poultry production is one of the major sub-sectors in Nigerian agricultural industry and produces bulk of these organic waste from livestock enterprises especially from commercialized poultry farms. Medium scale poultry enterprises are poultry farms having between 1001 and 5000 birds while large scale poultry enterprises are poultry farms having between 5001 and less than 10,000 birds [10]. [11] reported that under-developed infrastructure, lack of regulations and poor enforcement, barriers to moving waste from one country to another, and limited recycling opportunities due to economies of scale have stalled progress on sustainable waste management. Hence, there is the need for extensive knowledge and capacity building on the part of governments, professionals and the operators so that the benefits would be realizable. The inability of succeeding governments at various levels of Nigeria to effectively manage Municipal wastes (MW) has become a cause of concern. This may be curbed if awareness, attitude and behavioural intentions of medium and large scale poultry farmers to poultry waste management practices in Lagos State is known. The study becomes imperative.

Objectives of the Study

The aim of this study was to analyze awareness, attitude and behavioural intentions of medium and large scale poultry producers to poultry waste management practices in Lagos State.

2. Method

Study Area

The study was conducted in Lagos State. Lagos State is located in Southwest Nigeria on the west coast of Africa, within latitude $6^0 23'$ N and $6^0 41'$ N, and longitude $2^0 42'$ E and $3^0 42'$ E [12]. Lagos state has an estimated population of 9,113,605 with 4,719,125 males and 4,394,480 females [13]. The population of Lagos is currently estimated to be 21,883,047 million. Lagos economy is highly dependent on service revenue but urban agriculture is relatively minimal. The study area has tropical climate with distinct dry and wet seasons. The dry season is short and occurs between November and March while the wet season starts from April to October [14]. The climatic condition and vegetation pattern favours agricultural practice. Agricultural practices such as market gardening, poultry, snail, bee keeping and livestock farming are common [15]. Availability of farm location has brought relief pressure on some food items such as local and exotic vegetables, eggs, medicinal herbs, maize and chicken to urban household, hotels, food hawkers, foreign owned restaurants scattered all over the state.

Figure 1. Lagos state showing specific LGAs (by dots) in which Medium and Large scale farmers are predominant.

Source: Adapted and modified from Jide (2013)

Sampling procedure

The study population was medium and large scale poultry farmers in Lagos state, Nigeria. A list of registered poultry farmers was compiled with the assistance of staff in the Poultry Association of Nigeria (PAN), Lagos chapter which comprises 256 poultry enterprises (combination of micro-scale, small scale, medium and large scale). From the list, poultry farmers were differentiated according to Local Government Areas (LGAs), out of which ten of the twenty LGAs were

DOI: http://dx.doi.org/10.36956/njas.v4i1.472

purposively selected viz: Ikorodu, Epe, Ikeja, Agege, Oshodi-Isolo, Ibeju-Lekki, Ojo, Alimosho, Eti-Osa and Badagry based on available records of the highest number of registered members of the Poultry Association of Nigeria (PAN), Lagos state chapter. Also, poultry farmers from the purposively selected local government areas were also classified according to the type of enterprise/ scale of operation. This was based on the number of birds as medium scale enterprises (between 1001 and 5000 birds) and large scale enterprises (between 5001 and 10,000 birds) [15]. Giving us a total of 72 medium- and 53 large-scale registered poultry enterprises. Employing a simple random sampling, there was a random selection of six (6) medium scale poultry farmers and four (4) large scale (80%) poultry farmers from the selected ten LGAs, giving a total of sixty (60) medium scale poultry farmers and forty (40) large scale poultry farmers, making a grand total of one hundred (100) medium and large scale poultry farmers who were used for the study.

Data collection and Analysis

The study adopted a descriptive survey. A well-structured questionnaire was used to collect data on the waste management practices using a sample of medium and large scale poultry producers. Likert scale rating technique and Principal Component Analysis (PCA) were used to analyze the objective.

Five point Likert scale rating technique

Awareness, attitudes and behavioural intention

Medium and large scale poultry producers' awareness, attitude and behavioral intentions (AAB) relating to sustainable waste management; reduction, reuse, recycle, recover (composting) and safe disposal were obtained. For this purpose, a five point Likert scale method was used to develop 20 attitudinal statements. In the Likert scale, the option "Strongly Agree" was given the highest value of 5 and "Strongly disagree" was given a value of 1. The following scaling procedure was adopted: strongly agree (SA), agree (A), neutral (N), disagree (D), strongly disagree (SD). The values of the five responses were added and further divided by 5 to obtain mean score of 3.00,

$$\frac{5+4+3+2+1}{5}=3.0$$

which was regarded as the mean response level or benchmark to either accept or reject. Based on this, scores below 3.0 (MS<3.0) was taken as a weak factor and was not considered (rejected) while those with mean score of above 3.0 (MS>3.0) was taken as strong factors and considered (accepted).

Factor Analysis

To obtain a quantitative measure of the respondents' responses on awareness, attitude and behavioural (AAB) intentions relating to sustainable waste management, factor analysis was employed. The rule of thumb as was developed by [16] adopted a factor loading of 0.30 and above which was adopted in analysing the data obtained. A varimax rotated factor matrix was then employed to identify the most important factors. Only variables with factor loading of 0.30 and above were used in naming the factors. This implied that variables with coefficient greater than 0.30 were perceived to have high loading and were considered strong factors while those with less than 0.30 were considered minor factors. As was employed by various studies [17]; [18]. The principal component analysis model is stated thus:

$Y1 = a_{11}X_1 + a_{12}X_2 + \ldots + a1nXn$

$Y2 = a_{21}X_1 + a_{22}X_2 + \ldots + a2nXn$

$Y3 = a_{31}X_1 + a_{32}X_2 + \ldots + a3nXn$

. = .

. = .

. = .

$Yn = an_1X_1 + an_2X_2 + \ldots + annXn$

Where; $Y_1, Y_2 \ldots Yn$ = observed variables

$a_1 - an$ = factor loadings or correlation coefficients.

$X_1, X_2 \ldots Xn$ = unobserved underlying factors were used in naming the factors [19].

3. Results and Discussion

Descriptive information

Poultry waste related behavioural intentions are linked with awareness, attitude (including values, beliefs and norms), behavioural control, socio-economic variables and other factors. In that sense, poultry waste in relation to AAB were studied by obtaining the medium and large-scale poultry farmers' weighing for attitudinal statements using the five-point Likert scale method and the Principal Component Analysis (PCA). [20]stated that it is important to study individuals' behaviour, attitudes, and awareness about poultry waste management.

To understand the AAB of respondents regarding SPWM practices, the likert scale rating technique was used but in a bid to identify underlying variable or factors that explains the pattern of correlations within a set of observed variables, PCA was adopted. The average scores are presented in Table 1 and Table 2 for medium- and large-scale poultry producers, respectively.

DOI: http://dx.doi.org/10.36956/njas.v4i1.472

Frequency Scores for Attitudinal Statements of Medium Scale Poultry Producers in Lagos state, Nigeria

Table 1. Descriptive likert type information of AAB for sustainable poultry waste management by medium scale poultry producers.

	Sustainable poultry waste management	AWARENESS, ATTITUDE AND BEHAVIOURAL (AAB) INTENTIONS	SA/A	N	D/SD	SD	MEAN	REMARK
1.		I know how to make compost with poultry manure (@1)	29 (48.4)	17 (28.3)	14 (233)	1.346	3.52	ACCEPT
		I am aware that reducing waste is good for the sustainability of the city (@2)	23 (38.3)	13 (21.7)	24 (40.0)	1.578	3.18	ACCEPT
	Awareness/ perception	I am aware of the negative impact of poultry waste burning (@4)	22 (36.7)	9 (15.0)	29 (48.3)	1.783	2.85	REJECT
		I am aware of the negative impact of fly-tipping of poultry waste (V73)	31 (51.7)	10 (16.7)	19 (31.6)	1.544	3.43	ACCEPT
		I am aware that isolated dead birds are not to be disposed of with normal waste (V74)	23 (38.4)	16 (26.7)	21 (35.0)	1.503	3.25	ACCEPT
2.	**Attitudes**	I have no time to make compost with poultry manure (V59)	33 (55.0)	11 (18.3)	16 (26.7)	1.250	3.62	ACCEPT
		I have enough land to make compost with poultry manure (V60)	20 (33.3)	13 (21.7)	27 (45.0)	1.402	2.97	REJECT
		I don't think it's necessary to make compost before selling (V61)	34 (56.6)	11 (18.3)	15 (25.0)	1.427	3.78	ACCEPT
		I would reuse poultry dungs when the time comes (V64)	36 (60.0)	18 (30.0)	6 (10.0)	1.162	3.85	ACCEPT
		If there is not enough incentives for us to reuse and recycle, I wouldn't (V66)	31 (51.7)	16 (26.7)	13 (21.7)	1.451	3.72	ACCEPT
		I like it if someone collects recyclable poultry waste from my poultry farm for a fee (V68)	3 (5.0)	10 (16.7)	47 (78.3)	0.915	1.90	REJECT
		I like to separate poultry waste if there is a regular mobile collection for recyclable materials (V69)	36 (60.0)	8 (13.3)	16 (26.7)	1.432	3.87	ACCEPT
		I would like to take my recyclable waste to drop-in special recycling centers in Lagos state (V70)	26 (43.3)	15 (25.0)	19 (31.6)	1.277	3.38	ACCEPT
		I like it if the recyclable collection facilities are more frequently available in nooks and cranny of the city (V71)	28 (46.7)	12 (20.0)	20 (33.3)	1.523	3.47	ACCEPT
		The LAWMA should offer special service for isolated dead bird collection (V75)	49 (81.7)	8 (13.3)	3 (5.0)	0.985	4.25	ACCEPT
		Disposing of poultry waste in an environmentally friendly way is the responsibility of the LAWMA (V76)	50 (83.3)	5 (8.3)	5 (8.3)	0.963	4.57	ACCEPT
3.		I would like to minimize poultry waste by buying less packaging (V63)	33 (55.0)	12 (20.0)	15 (25.0)	1.339	3.73	ACCEPT
		I am reusing materials to reduce poultry waste (V65)	37 (61.7)	14 (23.3)	9 (15.0)	1.241	3.95	ACCEPT
	Behavioural Intentions	I am recycling poultry farm waste materials which can be recycled (@3)	31 (51.7)	8 (13.3)	21 (35.0)	1.508	3.62	ACCEPT
		We should protect the natural environment from waste for the sake of future generations	19 (31.7)	12 (20.0)	29 (48.3)	1.479	2.98	REJECT

Source: Computed from field survey, 2021.

SA/A = Strongly Agree/Agree; N= Neutral; D/SD= Disagree/Strongly Disagree; SD = Standard deviation;

 DOI: http://dx.doi.org/10.36956/njas.v4i1.472

PCA of the AAB for sustainable poultry waste management by Medium scale poultry enterprises

Table 2. Total Variance Explained of the Awareness, Attitude and Behavioural intentions (AAB) for sustainable poultry waste management by Medium scale poultry enterprises in Lagos State, Nigeria.

Components	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.771	13.857	13.857	2.771	13.857	13.857	2.017	10.085	10.085
2	2.571	12.855	26.712	2.571	12.855	26.712	1.962	9.810	19.895
3	2.020	10.099	36.812	2.020	10.099	36.812	1.871	9.353	29.249
4	1.721	8.604	45.416	1.721	8.604	45.416	1.799	8.997	38.245
5	1.518	7.592	53.009	1.518	7.592	53.009	1.738	8.688	46.933
6	1.467	7.333	60.342	1.467	7.333	60.342	1.644	8.220	55.153
7	1.074	5.370	65.712	1.074	5.370	65.712	1.594	7.972	63.125
8	1.031	5.156	70.868	1.031	5.156	70.868	1.549	7.743	70.868
9	0.981	4.907	75.775						
10	0.844	4.222	79.998						
11	0.758	3.791	83.788						
12	0.603	3.013	86.802						
13	0.521	2.604	89.406						
14	0.509	2.546	91.952						
15	0.393	1.967	93.920						
16	0.323	1.616	95.535						
17	0.273	1.364	96.899						
18	0.252	1.262	98.161						
19	0.233	1.164	99.325						
20	0.135	0.675	100.000						

Extraction Method: Principal Component Analysis (PCA).

Source: PCA result, 2021

Table 3. Component matrix of the AAB for medium-scale poultry producers

	Component							
	1	2	3	4	5	6	7	8
V75	0.614	-0.007	0.178	-0.212	-0.152	0.512	0.030	-0.280
V65	0.573	-0.049	-0.233	0.444	0.031	0.051	0.383	-0.256
V59	0.565	0.328	-0.153	-0.197	0.132	0.238	-0.145	-0.386
@1	0.548	0.109	0.145	-0.326	0.175	-0.151	-0.127	0.090
V77	0.533	-0.146	0.295	0.395	0.051	0.050	-0.390	0.130
@4	0.459	0.183	-0.123	-0.017	0.385	-0.358	0.215	0.137
V69	0.022	0.654	0.228	0.150	0.229	-0.433	0.018	-0.113
@2	0.290	0.641	0.157	-0.070	-0.215	-0.188	-0.337	0.023
V64	0.458	-0.603	0.223	-0.148	0.348	-0.032	0.160	0.030
V68	-0.308	0.570	0.178	0.001	-0.069	0.298	0.357	0.135
V76	0.040	-0.373	0.703	-0.121	0.114	-0.108	0.395	-0.030
V60	0.366	0.152	-0.561	0.125	-0.170	0.186	0.061	0.084
V74	0.130	0.358	0.381	0.336	-0.147	-0.310	0.079	-0.285
V66	0.200	0.186	0.158	-0.687	-0.147	-0.002	0.224	0.126
@3	0.243	-0.057	0.310	0.638	0.103	0.196	-0.010	0.407
V73	0.047	0.346	0.288	0.168	-0.549	0.092	0.309	0.032
V63	-0.181	0.258	-0.448	0.091	0.478	-0.187	0.226	-0.146
V61	-0.177	0.467	0.349	-0.186	0.478	0.276	-0.161	0.191
V70	-0.257	0.270	0.070	0.164	0.462	0.615	0.051	-0.104
V71	0.424	0.247	-0.379	-0.086	-0.058	0.026	0.183	0.567
Extraction Method: Principal Component Analysis.								
a. 8 components extracted.								

Source: PCA result, 2021

DOI: http://dx.doi.org/10.36956/njas.v4i1.472

Table 4. Rotated Component Matrix for medium scale poultry producers' AAB

	Component							
	1	2	3	4	5	6	7	8
V75	0.842	-0.167	0.124	0.019	0.129	0.009	0.189	0.109
V59	0.756	0.183	-0.215	0.118	-0.064	0.116	-0.151	0.167
@1	0.425	0.218	0.172	-0.097	0.086	0.411	-0.212	-0.171
V69	-0.082	0.833	-0.020	0.198	-0.048	0.111	0.025	0.001
V74	0.039	0.661	0.099	-0.090	0.139	-0.176	0.281	0.151
@2	0.307	0.585	-0.313	-0.068	0.102	0.181	0.186	-0.321
V76	-0.013	0.017	0.895	-0.026	0.066	-0.082	0.126	-0.033
V64	0.225	-0.244	0.647	-0.152	0.211	0.185	-0.372	0.159
V60	0.202	-0.169	-0.492	-0.099	0.039	0.331	0.078	0.351
V70	0.064	-0.089	-0.070	0.839	0.051	-0.197	0.000	0.119
V61	0.073	0.208	0.064	0.731	0.045	0.104	-0.054	-0.411
@3	-0.152	0.003	0.101	0.182	0.806	0.112	0.158	0.162
V77	0.246	0.117	0.048	-0.131	0.781	0.012	-0.139	0.004
V71	0.050	-0.115	-0.267	-0.038	0.079	0.796	0.133	0.076
@4	0.052	0.338	0.125	-0.011	0.008	0.574	-0.263	0.263
V66	0.350	-0.012	0.248	-0.049	-0.383	0.404	0.230	-0.331
V73	0.056	0.187	-0.001	-0.061	0.063	-0.004	0.770	0.042
V68	-0.103	0.127	-0.054	0.535	-0.183	0.081	0.575	-0.061
V65	0.248	0.061	-0.002	-0.122	0.203	0.139	0.048	0.809
V63	-0.256	0.211	-0.191	0.303	-0.362	0.145	-0.321	0.388

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 17 iterations.

Source: PCA result, 2021

Table 5. Expressed Rotated Component Matrix for medium scale poultry producers' AAB

Parameters	Component							
	1	2	3	4	5	6	7	8
The LAWMA should offer special service for isolated dead bird collection (V75)	**0.842**							
I have no time to make compost with poultry manure (V59)	**0.756**							
I know how to make compost with poultry manure (@1)	**0.425**							
I like to separate poultry waste if there is a regular mobile collection (V69)		**0.833**						
I am aware that isolated dead birds are not to be disposed with normal waste (V74)		**0.661**						
I am aware that reducing waste is good for the sustainability of the city (@2)		**0.585**						
Disposing of poultry waste in an environmentally friendly way is LAWMA'S duty (V76)			**0.895**					
I would reuse poultry dungs when the time comes (V64)			**0.647**					
I have enough land to make compost with poultry manure (V60)			**0.492**					
I would like to take my recyclable waste to drop-in special recycling centers in the state (V70)				0.839				
I don't think it's necessary to make compost before selling (V61)				0.731				
I am recycling poultry farm waste materials which can be recycled (@3)					0.806			
We should protect the natural environment from waste for the sake of future generations (V77)					0.781			
I like it if the recyclable collection facilities are more frequently available (V71)						0.796		
I am aware of the negative impact of poultry waste burning (@4)						0.574		
If there is not enough incentives for us to reuse and recycle, I wouldn't (V66)						0.404		
I am aware of the negative impact of the fly-tipping of poultry waste (V73)							0.770	
I like it if someone collects recyclable poultry waste from my poultry farm for a fee (V68)							0.575	
I am reusing materials to reduce poultry waste (V65)								0.809
I would like to minimize poultry waste by buying less packaging (V63)								

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 17 iterations. Three components selected

 DOI: http://dx.doi.org/10.36956/njas.v4i1.472

Table 6. Component Transformation Matrix for medium scale poultry producers' AAB

Components	1	2	3	4	5	6	7	8
1	0.667	0.123	0.081	-0.290	0.376	0.471	-0.083	0.281
2	0.132	0.635	-0.431	0.425	-0.170	0.240	0.340	-0.105
3	0.103	0.312	0.682	0.141	0.338	-0.249	0.294	-0.379
4	-0.375	0.193	-0.210	0.052	0.640	-0.260	0.120	0.533
5	-0.075	0.129	0.259	0.608	0.028	0.167	-0.701	0.149
6	0.411	-0.594	-0.150	0.571	0.177	-0.167	0.262	0.036
7	-0.172	-0.087	0.455	0.114	-0.370	0.294	0.446	0.566
8	-0.427	-0.265	-0.032	0.065	0.370	0.670	0.136	-0.372

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

Source: PCA result, 2021

Table 7. KMO and Bartlett's Test of Sphericity

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.761
Bartlett's Test of Sphericity	Approx. Chi-Square	328.781
	Degree of freedom	190
	Significance level	0.000

Source: PCA result, 2021

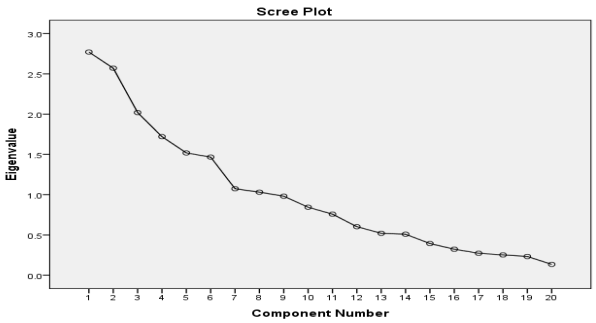


Figure 2. Scree plot of PCA for medium scale poultry producers AAB for sustainable poultry waste management in Lagos state, Nigeria.

Source: computed from field survey, 2021.

Principal Component analysis (PCA)

As presented in Table 2 to Table 6, Principal Component Analysis was used as a data reduction technique in order to group 20 statements into meaningful components and/or to select the most suitable components. In order to use these statements in the PCA, four conditions were fulfilled as suggested by [21]: (1) the sample size exceeded the minimum number of cases by having 300 cases; the number of cases were also more than three times greater than the number of statements; (2) correlation matrix with some coefficients being greater than 0.4; (3) the linearity of the relationships were assumed among variables, and (4) outliers were checked and removed. Kaiser's criterion, Scree test, and total variance were used to determine the number of components.

In Table 2, for the percentage variance under the rotated sums of squared loadings, it was evident that only 8 components met the cut-off point criterion. The percentage variance column tells us how much of the total variability can be accounted for by each of the summary components. For instance, factor one, two and three accounted for 10.085%, 9.810% and 9.353% respectively of the variability in all 20 variables. In Table 3, the component matrix was presented. It shows the initial solution before rotation, without showing the factor loading for each variable. Each number represented the correlation between the item and the unrotated factor (e.g. the correlation between V75 and factor one is 0.614). It is possible to see items with large loadings on several of the unrotated solution which made interpretation difficult. In this case, it was needful to examine a rotated solution which lead us to Table 4. It was pertinent to decide whether an orthogonal solution (employed if factors were not highly correlated) or oblique solution (specifically, Direct Oblimin if factors were correlated with one another). The varimax rotation was employed in the study because it gave the factor loadings for each individual variable in the data set which is what was used to interpret the meaning of the different factors. The expressed rotated component matrix in Table 5 highlighted the rotated factors that loaded more strongly (greater than or equal to 0.4). In the same table, the first three subsets loaded strongly on factor one, two and three and had Eigen value greater than 2. Table 5 showed the orthogonal solution

DOI: http://dx.doi.org/10.36956/njas.v4i1.472

while KMO and Bartlett's test were both measures of sampling adequacy and reveals multicollinearity (factors being highly correlated) problems.

According to the results of the PCA, the KMO measure of sampling adequacy is 0.761 (above 0.6) and Bartlett's test is 0.000 (significant because $p<0.05$). These results proved factorability and, hence, the principal component analysis was appropriate for the data set. There were eight components with eigenvalues greater than 1. These components explained the 70.868% of the total variance. The extracted eight components were presented in Table 5.

Scree plot (figure 1), which was developed using the eigenvalue, was used to find the break of the curve in order to determine the number of components. When checking the scree plot, it was also found that the curve started to level out after 8 components (for Eigen value equal to or greater than 1) but on Table 5, the rotated component matrix (that is, in the varimax with Kaiser Normalization), only subsets for the first three components loaded greatly and strongly with Eigen value greater than two and as such was named. Using Table 5, this test suggested a 3-component solution for the 20 statements and, therefore, a three-component solution was decided as the final solution. As suggested by [21], having a small subset with regard to components 4, 5, 6, 7 and 8 also proved the three component solution.

For the purpose of interpretation of the extracted components, the components were rotated using the Varimax rotation method only. This process helps to understand the pattern of loadings without changing the number of components [21]. Direct Oblimin rotation only assumes the correlations among the components. The loadings below 0.4 were dispensed with. The statements were arranged in the order of component loading in each factor. The three main components which were extracted were labelled by considering the statements belonging to them. The first component was named "Attitudes on poultry waste collection and composting" after the higher loading items such as V75, V59 and @1. The second component was called "Awareness and behavioural intentions related to recycling, sorting, and reduction" and considered items V69, V74 and @2. Some recycling related statements were loaded in this component. Finally, the third component was named "Attitudes related to poultry waste disposal and reuse" by considering items such as V76, V64 and V60. All three components extracted had three items in which the loadings were greater than 0.4. These three components explained the linkage between awareness, attitudes, and behavioural intentions relating to SPWM practices. These linkages provide invaluable insight regarding how these three components can be used to encourage medium scale poultry farmers to undertake sustainable poultry waste management (SPWM) practices.

Component one: Attitudes on poultry waste collection and composting

In this component, medium scale poultry farmers were of the view that the LAWMA offer special service for isolated dead bird collection (V75) being aware of the environmental and health implication of such mundane disposal modalities which contaminates the soil, waste land and pollute the farm environment; medium scale poultry farmers also reported having no time to make compost with poultry manures (V59) denoting nonchalance of medium scale poultry farmers who had little or no concern and possibly may prefer to dispose their waste in whatever way they please. A good number of them also claimed to know how to make compost (@1) possibly in the traditional or modern way but the bone of contention is not just in the know but the need to practice so as to reduce the amount of waste to be disposed of by LAWMA, incurement of LAWMA exorbitant fees, and illegal landfills. [22] also pointed out the importance of farmers' perceptions (on the required time and space) regarding composting and that there is a strong need to improve the awareness on composting, in order to reverse the negative thinking associated with it. This is very important as, according to the waste quantification results in this study, approximately 98.3% of PW in this area were organic waste (faecal matter) (Table 4). Most of the time, organic waste was not separated from the rest. In general, these findings confirm the need to improve the environmental knowledge of society.

Component two: Awareness and behavioural intentions related to recycling, sorting, and reduction

Awareness and behavioural intentions relating to recycling, sorting and reduction were as follows: medium scale poultry farmers would separate poultry waste if there were regular mobile collection for recyclable materials (V69), medium scale poultry farmers were aware that isolated birds were not to be disposed with normal waste (V74) and finally medium scale poultry farmers were aware that waste reduction was good for the sustainability of the city (@2).

According to these statements (V69, V74, @2), medium scale poultry farmers can be encouraged to recycle by LAWMA provision of separate waste collection service being offered for recyclable items,

 DOI: http://dx.doi.org/10.36956/njas.v4i1.472

drop-in collection centres being provided more frequently in the city and monetary incentives. [23] have further explained the need for these requirements by having five components such as; the better condition of Eco-Points, to have information on recycling, to simplify sorting and deposits, to be given material or moral incentives, and to have support and cooperation from others. This component contained a unique set of statements relating to recycling which did not have any cross-loadings. This finding was also in line with [24] in having a clear set of unique practices for recycling related component. A statement of waste reducing attitude (S2) was also listed under this component.

Some of the previous studies obtained a separate component for waste reduction [24, 25], whilst others combined it with other groups [24]. However, as waste reduction also works alongside recycling, this did not violate the concept. The link between attitudes and behavioural intention relating to recycling, which is explained by this component has a policy implication; by forming environmental attitudes, behavioural intentions can be improved (i.e. making a standard and enforcing it, poultry farmers behaviour automatically in tunes with the laid down standard).

[20] also supported the relationship between recycling related attitudes and behavioural intentions found in the current study. [23] have further grouped recycling related aspects. They obtained three components for recycling related attitudes (environment conservation, the pressure of social and personal norms and indifference). [26]'s study also yielded three components; perception of social pressure to recycle, perception of the ability to recycle and the attitude towards recycling. These showed that even small variations within recycling can be captured.

Component three: Attitudes and behavioural intentions related to poultry waste disposal and reuse

All the attitudes related to poultry waste disposal and reuse were loaded into this component (V76, V64, and V60). The statements which were loaded into this component proved that there is a relationship between attitude, behavioural intentions on waste disposal and reuse. The attitudes relating to disposal of poultry waste in an environmentally friendly manner was the responsibility of the LAWMA (V76), the re-use of poultry waste is at a time best known to the medium scale poultry farmer (V64) and medium scale poultry farmers claim to have enough land to make compost (V60). Again, inclusion of the re-use in this component signified need of awareness programmes and incentives for medium scale poultry farmers to form positive environmental attitudes by either re-using their poultry waste or disposing it properly and thereafter improving their behavioural intentions. Again, these links were not as simple as seen and there can be many hidden factors affecting SPWM practices. Some of them can be sufficient facilities, rules and regulations, economic incentives and many more reasons.

Table 8. Descriptive likert type information of AAB for sustainable poultry waste management by large scale poultry producers

			Parameters					
	Sustainable poultry waste management	**AWARENESS, ATTITUDE AND BEHAVIOURAL INTENTIONS (AAB)**	**SA/A**	**N**	**D/SD**	**S.D.**	**MEAN**	**REMARK**
1.	**Awareness/ perception**	I know how to make compost with poultry manure (@1)	13 (32.5)	14 (10.0)	23 (57.5)	1.516	2.90	REJECT
		I am aware that reducing waste is good for the sustainability of the city (@2)	25 (62.5)	3 (7.5)	12 (30.0)	1.565	3.75	ACCEPT
		I am aware of the negative impact of poultry waste burning (@4)	21 (52.5)	3 (7.5)	16 (40.0)	1.692	3.40	ACCEPT
		I am aware of the negative impact of fly-tipping of poultry waste (V73)	23 (57.5)	1 (2.5)	16 (40.0)	1.723	3.43	ACCEPT
		I am aware that isolated dead birds are not to be disposed of with normal waste (V74)	15 (37.5)	9 (22.5)	16 (40.0)	1.446	3.10	ACCEPT
2.	**Attitudes**	I have no time to make compost with poultry manure (V59)	14 (38.0)	2 (5.0)	24 (60.0)	1.630	2.90	REJECT
		I have enough land to make compost with poultry manure (V60)	23 (57.5)	4 (10.0)	13 (32.5)	1.625	2.78	REJECT
		I don't think it's necessary to make compost before selling (V61)	17 (42.5)	2 (5.0)	21 (52.5)	1.679	3.05	ACCEPT
		I would reuse poultry dungs when the time comes (V64)	25 (62.5)	3 (7.5)	12 (50.0)	1.625	3.78	ACCEPT

DOI: http://dx.doi.org/10.36956/njas.v4i1.472

		If there is not enough incentives for us to reuse and recycle, I wouldn't (V66)	24 (60.0)	5 (12.5)	11 (27.5)	1.645	3.75	ACCEPT
		I like it if someone collects recyclable poultry waste from my poultry farm for a fee (V68)	11 (27.5)	23 (57.5)	6 (15.0)	1.616	2.95	REJECT
		I like to separate poultry waste if there is a regular mobile collection for recyclable materials (V69)	17 (42.5)	5 (12.5)	18 (45.0)	1.613	3.25	ACCEPT
		I would like to take my recyclable waste to drop-in special recycling centers in Lagos state (V70)	14 (35.0)	6 (15.0)	20 (50.0)	1.363	2.70	REJECT
		I like it if the recyclable collection facilities are more frequently available in nooks and cranny of the city (V71)	9 (22.5)	13 (32.5)	17 (45.0)	1.203	2.70	REJECT
		The LAWMA should offer special service for isolated dead bird collection (V75)	17 (42.5)	5 (12.5)	18 (45.0)	1.693	3.18	ACCEPT
		Disposing of poultry waste in an environmentally friendly way is the responsibility of the LAWMA (V76)	21 (52.5)	2 (5.0)	17 (45.0)	1.760	3.33	ACCEPT
3.	**Behavioural Intentions**	I would like to minimize poultry waste by buying less packaging (V63)	23 (57.5)	9 (22.5)	8 (20.0)	1.292	3.85	ACCEPT
		I am reusing materials to reduce poultry waste (V65)	23 (57.5)	6 (15.0)	11 (27.5)	1.615	3.58	ACCEPT
		I am recycling poultry farm waste materials which can be recycled (@3)	14 (35.0)	7 (17.5)	19 (47.5)	1.559	3.33	ACCEPT
		We should protect the natural environment from waste for the sake of future generations (V77)	9 (22.5)	2 (5.0)	39 (72.5)	1.509	2.33	REJECT

SA/A = Strongly Agree/Agree; N= Neutral; D/SD= Disagree/Strongly Disagree; S.D. = Standard deviation**;**

Source: Computed from field survey, 2021

PCA of the AAB for sustainable poultry waste management by large scale poultry enterprises

Table 9. Total Variance Explained of the Awareness, Attitude and Behavioural intentions (AAB) for sustainable poultry waste management by large scale poultry enterprises in Lagos State, Nigeria.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.041	15.205	15.205	3.041	15.205	15.205	2.572	12.862	12.862
2	2.499	12.497	27.701	2.499	12.497	27.701	2.319	11.595	24.457
3	2.376	11.878	39.579	2.376	11.878	39.579	2.278	11.391	35.848
4	1.832	9.162	48.741	1.832	9.162	48.741	1.803	9.014	44.861
5	1.512	7.559	56.300	1.512	7.559	56.300	1.792	8.959	53.821
6	1.438	7.190	63.490	1.438	7.190	63.490	1.693	8.465	62.286
7	1.235	6.173	69.663	1.235	6.173	69.663	1.475	7.377	69.663
8	0.989	4.945	74.608						
9	0.800	4.000	78.608						
10	0.770	3.852	82.460						
11	0.675	3.377	85.837						
12	0.591	2.953	88.790						
13	0.486	2.432	91.222						
14	0.387	1.936	93.158						
15	0.363	1.817	94.974						
16	0.275	1.376	96.350						
17	0.268	1.342	97.691						
18	0.232	1.159	98.851						
19	0.146	0.728	99.579						
20	0.084	0.421	100.000						

Extraction Method: Principal Component Analysis.

Source: PCA result, 2021

 DOI: http://dx.doi.org/10.36956/njas.v4i1.472

Table 10. Component matrix for large scale poultry producers' AAB

	Components						
	1	2	3	4	5	6	7
V68	0.797	-0.096	-0.041	-0.006	-0.030	-0.034	-0.167
V69	0.636	-0.361	-0.164	0.027	0.129	0.041	-0.093
V76	0.629	0.219	0.475	-0.183	-0.065	0.010	0.102
V61	0.599	0.377	-0.354	-0.162	0.074	0.164	0.262
V74	0.598	-0.265	0.111	0.301	-0.090	-0.360	-0.201
V77	-0.476	0.312	0.254	0.288	0.330	-0.341	-0.126
@3	0.443	0.237	0.441	0.201	0.316	-0.172	0.135
V60	0.142	-0.692	0.043	-0.487	-0.017	0.132	0.182
V59	-0.040	0.667	-0.376	0.079	0.086	0.337	0.210
V75	-0.019	0.558	0.106	-0.397	-0.180	0.101	-0.484
@1	0.295	0.515	-0.394	-0.311	0.286	0.020	-0.031
V70	0.207	0.485	-0.300	0.326	-0.217	-0.403	0.218
V64	0.253	0.171	0.636	-0.120	-0.265	-0.271	0.331
V66	-0.072	0.171	0.624	-0.050	0.104	0.533	-0.139
V65	-0.291	-0.165	-0.421	0.114	-0.348	-0.196	0.209
V63	0.202	0.083	-0.033	0.684	-0.185	0.269	-0.050
V73	0.094	-0.147	0.106	0.615	0.274	0.276	-0.244
@2	0.108	-0.286	-0.361	-0.002	0.735	-0.003	0.172
@4	0.285	-0.111	-0.301	0.181	-0.498	0.411	-0.071
V71	-0.138	-0.061	0.347	0.213	0.006	0.341	0.644

Extraction Method: Principal Component Analysis.

a. 7 components extracted.

Source: PCA result, 2021

Table 11. Rotated Component matrix for large scale poultry producers' AAB

	Component						
	1	2	3	4	5	6	7
V76	0.756	0.122	0.223	-0.178	-0.081	0.205	0.025
@3	0.724	0.091	-0.205	0.148	0.160	0.094	0.064
V64	0.685	-0.147	-0.059	-0.364	-0.237	-0.045	0.283
V74	0.518	-0.325	0.230	0.113	0.299	-0.263	-0.331
V68	0.504	0.069	0.494	0.152	0.161	-0.028	-0.350
V59	-0.175	0.812	-0.100	-0.090	0.154	-0.024	0.166
@1	0.090	0.728	0.026	0.142	-0.185	0.010	-0.307
V61	0.289	0.703	0.382	0.126	-0.033	-0.117	-0.023
V77	-0.002	-0.065	-0.835	-0.002	0.103	0.014	-0.033
@4	-0.177	0.088	0.625	-0.245	0.371	-0.106	0.008
V60	-0.039	-0.388	0.554	0.285	-0.452	0.160	0.136
V69	0.272	-0.057	0.522	0.394	0.155	-0.025	-0.244
@2	-0.081	0.139	-0.005	0.875	-0.048	0.007	-0.017
V75	0.008	0.329	-0.099	-0.548	-0.176	0.350	-0.431
V63	0.051	0.061	0.116	-0.116	0.753	-0.100	0.124
V73	0.016	-0.136	-0.068	0.255	0.700	0.226	-0.004
V66	0.147	-0.010	-0.101	-0.244	0.133	0.761	0.228
V70	0.228	0.392	-0.147	-0.174	0.182	-0.662	-0.046
V65	-0.406	-0.098	0.062	-0.076	-0.051	-0.552	0.120
V71	0.093	-0.037	-0.018	0.025	0.094	0.113	0.829

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

Rotation converged in 10 iterations.

Source: PCA result, 2021

DOI: http://dx.doi.org/10.36956/njas.v4i1.472

Table 12. Expressed Rotated Component matrix for large scale poultry producers' AAB

Parameters	Component						
	1	2	3	4	5	6	7
Disposing of poultry waste in an environmentally friendly way is LAWMA'S duty (V76)	**0.756**						
I am recycling poultry farm waste materials which can be recycled (@3)	**0.724**						
I would reuse poultry dungs when the time comes (V64)	**0.685**						
I am aware that isolated dead birds are not to be disposed with normal waste (V74)	**0.518**						
I like it if someone collects recyclable poultry waste from my poultry farm for a fee (V68)	**0.504**						
I have no time to make compost with poultry manure (V59)		**0.812**					
I know how to make compost with poultry manure (@1)		**0.728**					
I don't think it's necessary to make compost before selling (V61)		**0.703**					
We should protect the natural environment from waste for the sake of future generations (V77)			**-0.835**				
I am aware of the negative impact of poultry waste burning (@4)			**0.625**				
I have enough land to make compost with poultry manure (V60)			**0.554**				
I like to separate poultry waste if there is a regular mobile collection (V69)			**0.522**				
I am aware that reducing waste is good for the sustainability of the city (@2)				0.875			
The LAWMA should offer special service for isolated dead bird collection (V75)				-0.548			
I would like to minimize poultry waste by buying less packaging (V63)					0.753		
I am aware of the negative impact of the fly-tipping of poultry waste (V73)					0.700		
If there is not enough incentives for us to reuse and recycle, I wouldn't (V66)						0.761	
I would like to take my recyclable waste to drop-in special recycling centers in the state (V70)						-0.662	
I am reusing materials to reduce poultry waste (V65)						-0.552	
I like it if the recyclable collection facilities are more frequently available (V71)						.	0.829
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. Rotation converged in 10 iterations.							

Source: PCA result, 2021

Table 13. Component transformation matrix for large scale poultry producers' AAB

Component	1	2	3	4	5	6	7
1	0.707	0.208	0.582	0.164	0.172	-0.055	-0.242
2	0.192	0.768	-0.425	-0.432	0.047	0.015	-0.065
3	0.565	-0.443	-0.276	-0.291	-0.028	0.498	0.273
4	0.036	-0.131	-0.236	0.076	0.896	-0.291	0.178
5	0.097	0.196	-0.406	0.810	-0.022	0.353	-0.074
6	-0.324	0.281	0.423	-0.058	0.311	0.645	0.348
7	0.170	0.192	0.064	0.188	-0.258	-0.351	0.840

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Source: PCA result, 2021

Table 14. KMO and Bartlett's Test of Sphericity

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.657
Bartlett's Test of Sphericity	Approx. Chi-Square	254.467
	Degree of freedom	190
	Significance level	0.001

Source: PCA result, 2021

 DOI: http://dx.doi.org/10.36956/njas.v4i1.472

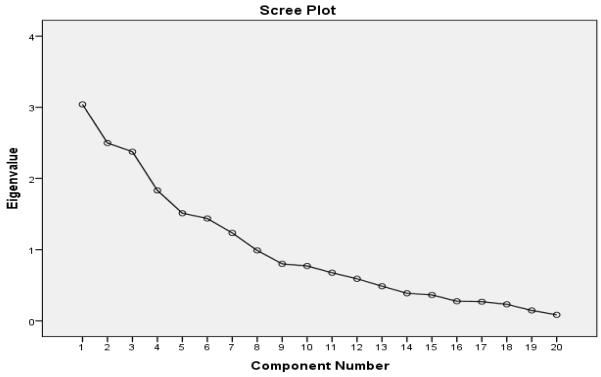


Figure 3. Scree plot of PCA for large scale poultry producers AAB for sustainable poultry waste management in Lagos State, Nigeria.

Source: computed from field survey, 2021

Principal Component analysis (PCA)

As described in Table 9 above, principal component analysis was used as a data reduction technique in order to group 20 statements into meaningful components and/or to select the most suitable components. Kaiser's criterion, Scree test, and total variance were used to determine the number of components. According to the results of the PCA, the KMO measure of sampling adequacy is 0.657 (above 0.6) and Bartlett's test is 0.001 (significant because $p<0.05$). These results prove factorability and, hence, the principal component analysis was appropriate for the data set. There were seven components with eigenvalues greater than 1. These components explained the 69.663% of the total variance. The extracted seven components are presented in Table 12.

In Table 9 labelled the total variance explained, the percentage (%) variance under the rotated sums of squared loadings, it was evident that only 7 components met the cut-off point criterion. The percentage variance column explained how much of the total variability can be accounted for by each of the summary scales or components. For instance, factor one, two and three accounted for 12.862%, 11.595% and 11.391% respectively of the variability in all 20 variables. In table 10, the component matrix was presented. It showed the initial solution before rotation, without showing the factor loading for each variable. Each number represented the correlation between the item and the unrotated factor (e.g. the correlation between V68 and factor one is 0.797). It is possible to see items with large loadings on several of the unrotated solution which made interpretations difficult. In this case, it was needful to also examine a rotated solution which led us to table 11. The varimax rotation was employed in the study because it gave the factor loadings for each individual variable in the data set which is what was used to interpret the meaning of the different factors. The expressed rotated component matrix in table 12 highlighted the rotated factors that loaded more strongly (greater than or equal to 0.4). In the same table, the first five subsets loaded strongly on factor one, three subsets on factor two and four subsets on factor three and had Eigen value greater than 2. Table 13 showed the orthogonal solution while KMO and Bartlett's test were both measures of sampling adequacy.

Scree plot (Figure 2), which was developed using the eigenvalue was used to find the break of the curve in order to determine the number of components. When checking the scree plot, it was also found that the curve started to level out after 7 components (for Eigen value equal to or greater than 1) but on table 12, the rotated component matrix (i.e. in the varimax with Kaiser Normalization), only subsets for the first three components loaded greatly and strongly with Eigen value greater than two and as such would be named. Using table 12, this test suggested a 3-component solution for the 20 statements and, therefore, a three-component solution was decided as the final solution. As suggested by [21], having a small subset with regard to components 4, 5, and 7 also proved the three component solution.

For the purpose of interpretation of the extracted components, the components were rotated using the Varimax rotation method only. The loadings below 0.4 were dispensed with. The statements were arranged in the order of component loading in each factor. The three main components which were extracted were labelled by considering the statements belonging to them. The first component was named "Attitudes on poultry waste disposal, recycling and reuse practices" after the higher loading items such as V76, @3, V64, V74 and V68. The second component was called "Attitude and Awareness related to composting of poultry waste" and considered items V59, @1 and V61. Finally, the third component was named as "Attitudes and Behavioural intentions related to poultry waste management" by considered items such as V77, @4, V60, and V69. All three components extracted had three items in which the loadings were greater than 0.4. These three components explained the linkage between awareness, attitudes, and behavioural intentions relating to SPWM practices. These linkages provided invaluable insight regarding how these three components can be used to encourage large scale poultry farmers to undertake SPWM practices.

DOI: http://dx.doi.org/10.36956/njas.v4i1.472

Component one: Attitudes on poultry waste disposal, recycling and reuse practices

All the statements relating to environmental concerns and attitudes apropos the harmful impact of poultry waste were, as expected, loaded into one component. The statement of large scale poultry farmer's attitude regarding poultry waste disposal, recycling and reuse practices in relation to the environment was grouped under the attitude statements (V76, @3, V64, V74 and V68) and are expressed as disposal of poultry waste in an environmentally friendly way is LAWMA's duty (V76), recycling poultry farm waste materials which can be recycled (@3), reusing poultry dungs when the time comes (V64), awareness that isolated dead birds are not to be disposed with normal waste (V74) and collection of recyclable poultry waste for a fee (V68).

From the result, it was hypothesized that the private sector participation (PSP) contractors of the Lagos Waste Management Agency (LAWMA) may not be performing up to expectations, LAWMA possibly may not be monitoring effectively the operations of the PSP and some large scale poultry farmers do not believe themselves as key actors to environmental friendly disposal of poultry waste.

From the result, it was revealed that good number of large scale poultry farmers recycled poultry waste that can be recycled. A low-temperature, catalytic tertiary conversion process for recycling organic materials is proposed for application to poultry litter and other animal waste. Current environmental problems associated with disposal of poultry wastes provide excellent opportunities for use of this recycling technology to minimize the volume of litter, manure, and modalities requiring disposal; sterilize litter material for reuse in multiple rotations; and reclaim valuable nutrient and mineral resources using a safe, closed system.

Component two: Attitude and Awareness related to composting of poultry waste

According to these statements (V59, @1 and V61), large scale poultry farmers can be encouraged to compost. The statements are explicitly expressed as lack of time to make compost with poultry manure (V59), knowledge of making compost with poultry manure (@1), and nonchalance to make compost before selling (V61).

From the result, large scale poultry farmers complained about lack of time to compost possibly because of several other farm engagements and concerns. From the other result, it's a common knowledge that composting organic waste and other biological material is much better than sending them as city dumps, where they would end up not being harnessed into methane gas. Time factor consideration was of two dimensions (1) time to make compost pile and (2) time it takes the compost to mature and a good knowledge on composting modalities can provide a long lasting solution to some waste management/environmental concerns and increases the value of compost sold to crop farmers by some of these large scale poultry farmers.

Component three: Attitudes and Behavioural intentions related to poultry waste management

All the attitudes and behavioural intentions related to poultry waste general management were loaded into this component (V77, @4, V60 and V69). The statements which were loaded into this component proved that there is a relationship between attitude and behavioural intentions on poultry waste management. The attitudes cum behavioural intentions were expressed as: protection of the natural environment from waste for the sake of future generations (V77), awareness of the negative impact of poultry waste burning (@4), having enough land to make compost with poultry manure (V60) and separation of poultry waste if there is a regular mobile collection (V69).

The capacity of the natural environment to absorb and process these poultry waste materials is also under stress. Valuable resources in the form of matter and energy are lost during waste disposal and burning, requiring that a greater burden be placed on ecosystems to remedy the situation. Most contemporary poultry waste management efforts were focused at local government level and some were based on high tech / high energy waste disposal methods such as sanitary landfill and incineration (bio-burning) which better protects the natural environment. However, these methods are becoming increasingly expensive and energy inefficient. The financial costs of managing the long-term environmental impacts of waste disposal are many times what is actually charged for this regular LAWMA services and in many cases corrective action is not remotely feasible. The purely environmental costs such as negative effects on habitat, wildlife and biodiversity are also recognized. In other words, waste management is not sustainable and will have negative implications for future generations.

4. Conclusions and Recommendations

Awareness and knowledge play a major role in the SPWM practices of poultry farmers in developing

 DOI: http://dx.doi.org/10.36956/njas.v4i1.472

countries. The resultant links between the awareness, attitudes and behavioural intentions regarding recycling and composting revealed the importance of awareness in engaging in SPWM practices. Based on the findings of this study, the following recommendations were made:

1) It is important to offer awareness campaigns in order to improve environmental knowledge and encourage environmental enthusiasm amongst society.

2) Although, general waste education is contained in the school curriculum, it is important to include more detailed information regarding organic waste management.

References

[1] Ikebude, C.F., 2017. Feasibility study on solid waste management in Port Harcourt Metropolis: Causes, effects and possible solutions. Nigerian Journal of Technology. 36(1), 276-281.

[2] Rahji, M.A.Y., Oloruntoba, E.O., 2009. Determinants of households' willingness-to-pay for private solid waste management services in Ibadan, Nigeria. Waste Management & Research. 27(10), 961-965.

[3] Ziraba, A.K., Haregu, T.N., Mberu, B., 2016. A review and framework for understanding the potential impact of poor solid waste management on health in developing countries. Archives of Public Health. 74(55), 1-11.

[4] United Nations Environment Programme (UNEP), 2015. Solid Waste Management. Volume II– Regional Overviews and Information Sources. ISBN: 92-807-2676.

[5] Apantaku, S.O., Oloruntoba, A., Fakoya, E.O., 2015. Farmers' involvement in agricultural problems identification and prioritization in Ogun State Nigeria. South African Journal of Agricultural Extension. 32, 45-59.

[6] Onuminya, T.O., Nze, E.C., 2017. An appraisal of waste management in Lagos Metropolis: A case study of Lagos State Waste Management Authority (LAWMA). Nigerian Journal of Pure and Applied Sciences. 30(3), 3104-3108.

[7] Adeyemo, A.A., Onikoyi, M.P., 2012. Prospects and challenges of large scale commercial poultry production in Nigeria. Agricultural Journal. 7(6), 388-393.

[8] Adeoye, P.A., Hasfalina, C.M., Amin, M.S.M., Thamer, A.M., Akinbile, C.O., 2014. Environmental implication of poultry waste generation and management techniques in Minna, Semi-arid Region of Nigeria. Annual Research & Review in Biology. 4(10), 1669-1681.

[9] Bamiro, O.M., Phillip, D.O.A., Momoh, S., 2006. Vertical integration and technical efficiency in poultry (egg) industry in Ogun and Oyo states, Nigeria. International Journal of Poultry of Science. 5(12), 1164-1171.

[10] Food and Agricultural Organization (FAO), 2007. Current World Fertilizer Situation and Outlook 1994/95-2000/2001. FAO/UNIDO/World bank Working Group on fertilizers, Rome.

[11] Fuldauer, L.I., Ives, M.C., Adshead, D., Thacker, S., Hall, J.W., 2019. Participatory planning of the future of waste management in small island developing state to deliver on the sustainable development goals. Journal of Cleaner Production. 223, 147-162.

[12] Quan, H., Igbasi, U., Oyibo, W., Omilabu, S., Chen, S.B., Shen, H.M., Okolie, C., Chen, J.H., Zhou, X.N., 2020. High multiple mutations of Plasmodium falciparum-resistant genotypes to sulphadoxine- pyrimethamine in Lagos, Nigeria. Infectious Diseases of Poverty, 9(91). Retrieved Sept 10, 2021 from https://link.springer.com/article/10.1186/s40249-020-00712-4.

[12] National Population Commission (NPC), 2006. The Population Census: of the Federal Republic of Nigeria Analytical report at the National Population Commission- Abuja. Retrieved October 16, 2007, from http://www.nigerianmuse.com.

[13] Adeonipekun, P.A., Oyebanji, O., Adebayo, M.B., Bamigbade, O.S., 2019. Distribution and sporulation phenology of pteridophytes in Lagos State, Nigeria. International Journal of Botany Studies. 4(2), 72-80.

[14] Adedayo, V., 2020. Potentials and contributions of urban and peri-urban agriculture to the Lagos Megacity Region. Journal of Agriculture and Sustainability. 5(2), 171-187.

[15] Omotosho, N., Oladele, F.B., 2008. Low Greenhouse Gas Agriculture: Mitigation and Adaptation Potential of Sustainable Farming Systems; Food and Agriculture Organization of the United Nations (FAO): Rome, Italy.

[16] Kessler, J., 2006. Environmental Politics in Japan: Networks of Power and Protest; Cambridge University Press: Cambridge, UK, www.nfuonline.com (Accessed on 10 February 2006).

[17] Amusa, T.A., Enete, A.A., Okon, U.E., 2011. Socioeconomic determinants of cocoyam production among small holder farmers in Ekiti state, Nigeria. Department of Agricultural Economics, University of Nigeria, Nsukka. International Journal of Agricultural Economics & Rural Development. 4(2).

[18] Solagberu Adisa, R., Oluwasegun A. Adekunle, 2010. Farmer-Herdsmen Conflicts: A Factor Analysis of Socio-economic Conflict Variables among Arable

DOI: http://dx.doi.org/10.36956/njas.v4i1.472

Crop Farmers in North Central Nigeria. Kamla-Raj Journal of Human Ecology. 30(1), 1-9.

[19] Madukwe, P., 2004. Measuring the Impact of Corporate Social Responsibility on Consumer Behavior: The Case of Peruvian Consumers. Paper presented at the Doctoral consortium, Cladea's annual assembly: Florida International University, Miami Retrieved from http://www.revistaleadership.com/cladea/doctoral/ coloquio_V/Marquina.pdf (October 28-29).

[20] Pakpour, A.H., Zeidi, I.M., Emamjomeh, M.M., Asefzadeh, S., Pearson, H., 2014. Household waste behaviours among a community sample in Iran: an application of the theory of planned behaviour. Waste Management. 34(6), 980-986.
DOI: http://dx. doi:10.1016/j.wasman.2013.10.028.

[21] Pallent, J., 2005. SPSS Survival manual. A step by step guide to data analysis using SPSS version 12 (2nd ed.). Maidenhead: Open University Press. Retrieved from http://www.academia.dk/BiologiskAntropologi/Epidemiologi/PDF/SPSS_Manual_Ver12

[22] Ferrara, I., 2008. Waste Generation and Recycling. OECD Journal: General Papers, 2. Retrieved 10/09/21 from https://www.oecd-ilibrary.org/economics/waste-generation-and-recycling_gen_papers-v2008-art10-en.

[23] Vicente, P., Reis, E., 2007. Segmenting households according to recycling attitudes in a Portuguese urban area. Resources, Conservation and Recycling. 52(1), 1-12.

[24] Barr, S., Gilg, A., Ford, N., 2005. Defining the multi-dimensional aspects of household waste management: A study of reported behavior in Devon. Resources, Conservation and Recycling. 45(2), 172-192.

[25] Marques, E., Lyons, J., Tucker, D., 2008. Avoiding, minimizing and mitigating the impacts of renewable energy development on wildlife: and important lands and natural resources, defenders of wildlife.

[26] Knussen, C., Yule, F., Mackenzie, J., Wells, M., 2004. An analysis of intentions to recycle household wastes: The roles of past behaviour, perceived habit, and perceived lack of facilities. Journal of Environmental Psychology. 24(2), 237-246.

 DOI: http://dx.doi.org/10.36956/njas.v4i1.472

Author Guidelines

This document provides some guidelines to authors for submission in order to work towards a seamless submission process. While complete adherence to the following guidelines is not enforced, authors should note that following through with the guidelines will be helpful in expediting the copyediting and proofreading processes, and allow for improved readability during the review process.

Ⅰ. Format

- Program: Microsoft Word (preferred)
- Font: Times New Roman
- Size: 12
- Style: Normal
- Paragraph: Justified
- Required Documents

Ⅱ. Cover Letter

All articles should include a cover letter as a separate document.

The cover letter should include:

- Names and affiliation of author(s)

The corresponding author should be identified.

Eg. Department, University, Province/City/State, Postal Code, Country

- A brief description of the novelty and importance of the findings detailed in the paper

Declaration

v Conflict of Interest

Examples of conflicts of interest include (but are not limited to):

- Research grants
- Honoria
- Employment or consultation
- Project sponsors
- Author’s position on advisory boards or board of directors/management relationships
- Multiple affiliation
- Other financial relationships/support
- Informed Consent

This section confirms that written consent was obtained from all participants prior to the study.

- Ethical Approval

Eg. The paper received the ethical approval of XXX Ethics Committee.

- Trial Registration

Eg. Name of Trial Registry: Trial Registration Number

- Contributorship

The role(s) that each author undertook should be reflected in this section. This section affirms that each credited author has had a significant contribution to the article.

1. Main Manuscript
2. Reference List
3. Supplementary Data/Information

Supplementary figures, small tables, text etc.

As supplementary data/information is not copyedited/proofread, kindly ensure that the section is free from errors, and is presented clearly.

Ⅲ. Abstract

A general introduction to the research topic of the paper should be provided, along with a brief summary of its main results and implications. Kindly ensure the abstract is self-contained and remains readable to a wider audience. The abstract should also be kept to a maximum of 200 words.

Authors should also include 5-8 keywords after the abstract, separated by a semi-colon, avoiding the words already used in the title of the article.

Abstract and keywords should be reflected as font size 14.

Ⅳ. Title

The title should not exceed 50 words. Authors are encouraged to keep their titles succinct and relevant.

Titles should be reflected as font size 26, and in bold type.

Ⅳ. Section Headings

Section headings, sub-headings, and sub-subheadings should be differentiated by font size.

Section Headings: Font size 22, bold type

Sub-Headings: Font size 16, bold type

Sub-Subheadings: Font size 14, bold type

Main Manuscript Outline

Ⅴ. Introduction

The introduction should highlight the significance of the research conducted, in particular, in relation to current state of research in the field. A clear research objective should be conveyed within a single sentence.

Ⅵ. Methodology/Methods

In this section, the methods used to obtain the results in the paper should be clearly elucidated. This allows readers to be able to replicate the study in the future. Authors should ensure that any references made to other research or experiments should be clearly cited.

Ⅶ. Results

In this section, the results of experiments conducted should be detailed. The results should not be discussed at length in

this section. Alternatively, Results and Discussion can also be combined to a single section.

Ⅷ. Discussion

In this section, the results of the experiments conducted can be discussed in detail. Authors should discuss the direct and indirect implications of their findings, and also discuss if the results obtain reflect the current state of research in the field. Applications for the research should be discussed in this section. Suggestions for future research can also be discussed in this section.

Ⅸ. Conclusion

This section offers closure for the paper. An effective conclusion will need to sum up the principal findings of the papers, and its implications for further research.

Ⅹ. References

References should be included as a separate page from the main manuscript. For parts of the manuscript that have referenced a particular source, a superscript (ie. [x]) should be included next to the referenced text.

[x] refers to the allocated number of the source under the Reference List (eg. [1], [2], [3])

In the References section, the corresponding source should be referenced as:

[x] Author(s). Article Title [Publication Type]. Journal Name, Vol. No., Issue No.: Page numbers. (DOI number)

Ⅺ. Glossary of Publication Type

J = Journal/Magazine

M = Monograph/Book

C = (Article) Collection

D = Dissertation/Thesis

P = Patent

S = Standards

N = Newspapers

R = Reports

Kindly note that the order of appearance of the referenced source should follow its order of appearance in the main manuscript.

Graphs, Figures, Tables, and Equations

Graphs, figures and tables should be labelled closely below it and aligned to the center. Each data presentation type should be labelled as Graph, Figure, or Table, and its sequence should be in running order, separate from each other.

Equations should be aligned to the left, and numbered with in running order with its number in parenthesis (aligned right).

Ⅻ. Others

Conflicts of interest, acknowledgements, and publication ethics should also be declared in the final version of the manuscript. Instructions have been provided as its counterpart under Cover Letter.

About the Publisher

The Nan Yang Academy of Sciences (NASS) is an international publisher of online, open access and scholarly peer-reviewed journals covering a wide range of academic disciplines including science, technology, medicine, engineering,education and social science. Reflecting the latest research from a broad sweep of subjects, our content is accessible worldwide – both in print and online.

NASS aims to provide an analytics as well as platform for information exchange and discussion that help organizations and professionals in advancing society for the betterment of mankind. NASS hopes to be indexed by well-known databases in order to expand its reach to the science community, and eventually grow to be a reputable publisher recognized by scholars and researchers around the world.

Database Inclusion

Asia & Pacific Science Citation Index

Creative Commons

China National Knowledge Infrastructure

Google Scholar

Crossref

MyScienceWork

Nanyang Academy of Sciences Pte. Ltd.
Tel.:+65 65881289
E-mail:contact@nassg.org
Add.:12 Eu Tong Sen Street #07-169 Singapore 059819