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FOREWARD

  

2019 has been a remarkable year in the recent history of CSIR-Animal Research Institute (CSIR-ARI) as it would be remembered as the year CSIR-ARI experienced the leadership of three Directors. Prof. E. K. Adu retired in June, 2019 having led the Institute for the past four years. Prof. P. A. Wallace took over the leadership mantle as Acting Director from July to October, 2019 until Dr. E. D. O. Ansa was appointed as substantive Director in November, 2019.

CSIR-ARI is poised to move to the next level and several changes are anticipated. In his induction speech as Director, Dr. E. D. O. Ansa indicated that every staff would be expected to contribute to the advancement of CSIR-ARI through a spirit of teamwork. The corporate brand would be vigorously promoted as CSIR-ARI seeks to enhance its visibility and commercial potential.

Commercialization of research output would be given a boost by the creation of a Commercial Unit which would take over the work of sales and marketing previously done by the New Products Development and Marketing Division. It would unify production, sales and marketing under one headship. CSIR-ARI hopes to strengthen existing partnerships with key Government agencies and the private sector. New partnerships would also be initiated locally and internationally to build capacity and to increase productivity.

CSIR-ARI would like to thank all our stakeholders for their continued support and partnership.

EXECUTIVE SUMMARY

Research and Development (R & D) activities at the CSIR-Animal Research Institute in 2019 covered areas focused on achieving food security and wealth creation in the livestock and poultry industry, promoting animal health and biosafety as well as developing and transferring technologies to farmers, promoting the small ruminant and poultry value chains.

Animal producers need to select superior animals for breeding in order to improve their herds' performance. Research on breeding focused on identifying traits in the Ashanti Black Pig of Ghana that can enable it to adapt to stressful environmental conditions. A prototype software has also been developed for dairy producers to monitor and visualize herds, comparing them with defined benchmarks. This technology can be applied to other livestock species for genetic evaluations. Field trials of improved feed troughs for small ruminant farmers were also successfully conducted showing that these improved feed troughs save up to 36% of feed compared to traditional methods of feeding. Research on feed from housefly and black soldier larvae as ingredient (sources of protein) for poultry feed also continued. As feed constitute a significant part of the cost of animal production, developing a simple, cheap but effective and safe technology for converting waste to feed ingredients continue to be a top priority. Focus currently is on processing hatchery waste into useful but safe protein alternative in place of the conventional and expensive fishmeal in normal pig rations

Pasture development at Nkwanta Livestock Station is currently on=going. Sixteen (16) acres of pasture fields comprising 8.5 acres of *Cajanus cajan,* 3.5 acres of *Gliricidia sepium,* 2 acres of *Digitaria decumbens* and 2 acres of *Brachiaria brizantha* have been established. The next phase of the project activities would involve the transfer of some of the newly developed breeds of sheep (by CSIR-ARI) to the station. Research has also focused on the development of climate-smart multi-species fodder banks for increased small ruminant production as well as income generation in northern Ghana.

Research on Animal Health and Biosafety focused on the effect of animal trypanosomes and tick-borne parasites co-infection on cattle immunity, risk assessment of *Campylobacter* in retail chicken in Accra, Ghana and the development of treatment schedule for the control of *Emeria* infestation in rabbits in Ghana. Additionally, epidemiological studies of the influenza virus in poultry and pigs as well as their handlers were conducted. Preliminary findings suggest that there is the need to educate farmers on biosafety measures to reduce the incidence of reverse zoonoses.

Farmer training workshops were conducted to assess knowledge in the used of technologies transferred. The assessments showed that farmers are well- informed on the storage, mode of application of drugs, biosecurity measures likewise proper farm management protocols Most of the farmers saw an increment in their profit margins.

In all, fourteen (14) refereed journal articles, seven (7) technical papers, seven (7) conference papers were produced.

INTRODUCTION

Animal Research Institute (ARI) is one of the thirteen (13) Research Institutes of the Council for Scientific and Industrial Research (CSIR). The history of CSIR-ARI dates back to 1957. It began as a Parasitological and Entomological Research Unit until 1965 when it was expanded and given a national mandate to undertake research and development in all aspects of poultry and livestock production in Ghana.

1.1 Corporate Mandate, Vision and Mission

Mandate:

To develop and transfer technologies that promote livestock and poultry production in Ghana.

Mission:

Our mission is to inspire efficiency and entrepreneurship in the Ghanaian livestock industry through technology development and innovative interventions for food security and wealth creation.

1.2 Core competence

- Pig and poultry production
- Quality feed formulations from both conventional and unconventional feeding stuffs
- Livestock and poultry disease control
- Grasscutter production
- Dairy production
- Livestock production economics
- Participatory improvement in small ruminants
- Training and Consultancy Services in animal production and health

FOOD SECURITY AND POVERTY REDUCTION: LIVESTOCK AND POULTRY

Genomic analysis in search for admixture and selection footprints in local pig population in a tropical environment

K. A. Darfour-Oduro

The Ashanti Black Pig (ABP) of Ghana has adaptive traits which may be absent in other international domestic pigs. Despite the presumed adaptive traits of the ABP, there has been no report on genomic signatures of adaptation of the ABP. A recent study reported limited introgression and genomic signatures of selection in local pigs of the Kenya Homabay region (KHB pigs). Identification of genomic regions under selective pressure is necessary to design local African pig improvement strategies for prevailing environmental challenges and for crossbreds that seek to combine the high productivity in commercials breeds and adaptive traits of the local African pigs. The objective of this study is to determine evidence of admixture from worldwide reference panel of pigs in ABP and KHB pig populations and to determine whether specific regions within the genomes of ABP and KHB pig populations have been under natural selective pressures and whether these regions coincide in the two pig populations.

A total of 602 samples belonging to 36 breeds/populations were analyzed (Table 1). The KHBs were genotyped with the Illumina PorcineSNP80 BeadChip. SNP genotype data from 34 populations, characterized using Illumina PorcineSNP60 BeadChip, were also taken from a previous study on population structure and introgression of worldwide pig populations. Populations from which these SNP genotype data were obtained, constituted reference populations for this study and were selected based on their potential as founders of African pig populations.

SNPs that did not map or mapped to multiple locations on the pig genome assembly *Sus scrofa* (SSC) build 10.2 were discarded from the ABP and KHB genotype data. Non-autosomal SNPs were also discarded from the ABP, KHB and the reference populations genotype data. The same quality control filters were applied to each population separately, treating the reference populations as a single unit. The ABP, KHB and reference populations were then merged. A dataset of 36,449 SNPs (after SNPs in LD pruning) for 602 individuals was used for multi-dimensional scale (MDS) and admixture analysis and a dataset of 48,241 SNPs for 602 individuals were involved in selection analysis. Population stratification was assessed by MDS with 2 dimensions extracted, with PLINK v1.9 option: --cluster –mds-plot 2. The 2 dimensions (C1 vs C2) were plotted using R. To further quantify the different ancestry proportions of the ABP and KHB pig breeds, I carried out several unsupervised hierarchical clustering analyses using different number K of predefined clusters.

Table 1: Breeds and their Country of origin

Group	Breed	Acronym	N	Country of origin
ABP	Ashanti Black pig	ABP	44	Ghana
AD	Jinhua	CNJH	20	China
	Jiangquhai	CNJQ	11	China
	Meishan	CNMS	20	China
	Xiang	CNXI	13	China
	Zang	CNZA	19	China
AWB	Southern Wild boar	CNWB1	5	China
	Northern Wild boar	CNWB2	5	China
	Nanchang Wild boar	CNWB3	15	China
EC	Landrace	LDR	20	Netherlands
	Large White	LWT	20	Netherlands
	Pietrain	PIT	20	Netherlands
	Hampshire	HS	20	United Kingdom
ECD	Duroc	DUR	19	Denmark
EL	Mangalica	HUMA	20	Hungary
	Calabrese	ITCA	15	Italy
	Cinta Senese	ITCS	13	Italy
	Casertana	ITCT	15	Italy
	Nera Siciliana	ITNS	15	Italy
	Linderoth	SELI	15	Sweden
	Berkshire	UKBK	20	United Kingdom
EWB	Samoa Wild boar	GRWB	7	Greece
	Wild boar	HRWB	16	Croatia
	Wild boar	ITWB	19	Italy
	Wild boar	NEWB	20	Netherlands & France
	Wild boar	PLWB	8	Poland
	S. Balkan Wild boar	SBWB	20	Greece
IP	Chato Murciano	ESCM	20	Spain
	Iberian	ESIB	20	Spain
	Manchado de Jabugo	ESMJ	7	Spain
	Bisaro	PTBI	15	Portugal
IWB	Iberian Wild boar	IWB	18	Spain & Portugal
KD	Kenya domestic	KD	9	Kenya
KHB	Kenya Homabay	KHB	32	Kenya
LXM	LWT X Meishan	LXM	20	Netherlands
TWB	Wild boar	TWB	7	Tunisia

MDS and admixture results suggested that the ABP and KHB pigs (both local pigs from Africa) were admixed (fig. 1) with contributions from pigs of Asian and European ancestries. However, the contribution of European ancestry to the local Africa pigs genome seems higher given that the African local pigs cluster more closely with the European pigs than the Asian pigs (Fig. 1A) and they also have a higher proportion of European ancestry (red color) in their genomes (Fig. 1B).

The genomes of local pigs in Africa has been shaped by introgression from pig breeds from Asia and European continent. The next step in this project is to investigate how this complexity of the genomes of the local pigs in Africa have aided in their adaptation to the stressful environment they find themselves.

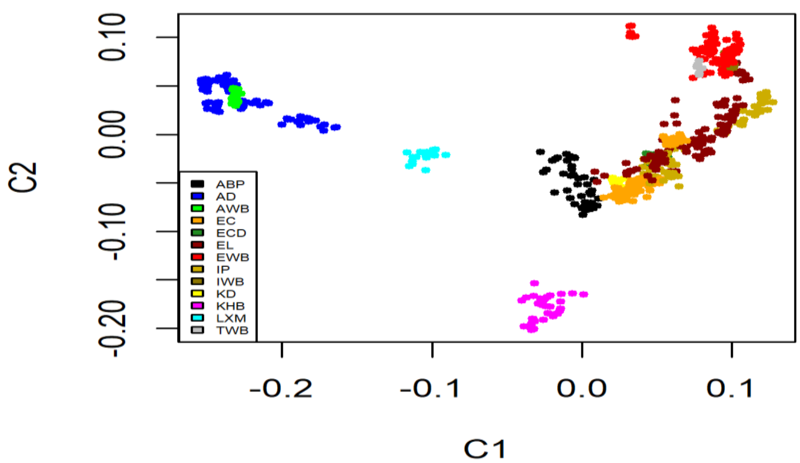

Fig. 1 A. Multi-dimensional scaling analysis of pig populations of ABP, KHB and reference panel of pigs**.**

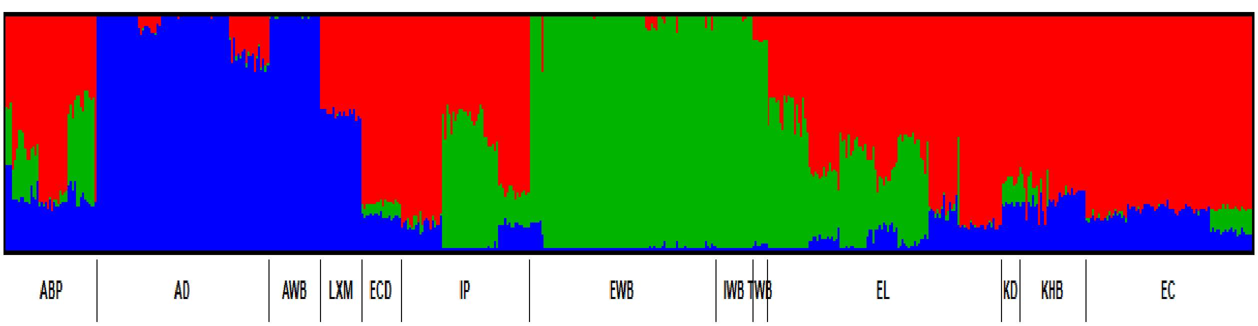

Fig. 1 B. Population structure analysis of ABP and KHB individuals at *K=3* inferred ancestral populations using a genome-wide panel of 36,449 SNPs. Each individual is shown as a vertical bar with ancestry indicated by color.

Efficient feed utilization through the use of improved feed troughs

S. Salifu and S. Konlan

The usual methods smallholder farmers use in feeding the available feed resources to their livestock is characterized by waste as animals eat portions trample and urinate on the rest, thereby contaminating the feed . Given the feed shortage particularly in the dry season, efficient utilization of the available feed resources is essential to minimize waste and therefore, have more feed available for more more animals. This study was designed to test, validate and demonstrate the effect of improved feed troughs on feed utilization by small ruminants in the Northern and Upper East Regions and to also build the capacity of smallholder livestock keepers in the management of improved feeding systems to reduce waste and hence improve animal productivity. The study was conducted in three communities in the Africa RISING zone of influence in the Northern Region (Tibali and Duko) and Upper East Region (Gia). Forty-five farmers (15 from each community) were selected from the intervention communities to participate in the study Feed use efficiency (reduction in wastage) was monitored in the wet and early dry seasons over a six day period. The quantity of feed offered (both in the morning and afternoon) and that wasted during the feeding process were measured for the six consecutive day period both for the traditional practice (spreading a portion of the feed on the ground) and wooden troughs. The amount of time spent in looking after the animals while feeding was poing on (bringing back dispersed feed, keeping animals to feed comfortably among others) were recorded for both practices. Quality of feed and leftover feed were also assessed. A questionnaire was administered to all participating farmers in order to document their opinions about the contribution of the technology and its acceptance relative to them. A simple cost-benefit analysis of the improved feed trough was conducted. Samples of the feed offered and the left-overs analyzed in order to to assess the quality of both the improved feed troughs and traditional feeding practice. A survey on the adoption of the technology within and outside the intervention communities were conducted in order to characterize the adopters and non-adopters as well as the drivers of adoption.

Less than 1% of feed was determined to have been wasted when the small ruminants were fed using the improved feed trough at all locations. An average of 36%, 25% and 22% of feed was however, wasted when the animals were fed by the conventional (traditional) means. Time spent on feeding was almost halved when the animals were fed with the improved trough since farmers could offer a complete day’s ration of feed at once, unlike in the case of the other means of feeding where the farmer needed to attend to animals as they fed. An associated benefit of the improved trough was the inspiration it gave farmers in the Northern Region (Duko and Tibali) to build a small fence (run) around the feed trough to prevent stray animals from accessing feed offered to their animals.

- Improved feed trough saved up to 36% feed compared to the traditional methods of feeding small ruminants in the target communities.
- Time spent feeding small ruminant was halved as a result of using the improved feed trough

- The current cost of constructing the feed trough is high (Ghc1,149.00) and the use of local materials such as neem, teak and thatch will need to be considered in future work.


Plate 1: Improved feed troughs Plate 2: Feeding from the improved feed trough


Plate 3: Farmer in Gia offers fresh grass to her sheep Plate 4: Feeding from conventional feed trough

Pasture and Livestock development at Nkwanta Station for improved small ruminant breeds for the Eastern Corridor of Ghana

Charles Y. F. Domozoro, E. Marfo-Ahenkora, B. Ato Hagan, E. T. Sottie, E. K. Adu, P. A. Wallace, K. Owusu-Ansah and M. Awudu

The CSIR-Animal Research, about five years ago, embarked on a breeding project with support from the Canadian International Development Agency (CIDA) and Ministry of Local

Government and Rural Development (MLGRD). The aim was to develop new breeds of sheep and goats with growth performance and survivability comparable to the Sahelian indigenous Djallonke breeds respectively. The newly developed sheep breed, has however, been tested and raised only in the northern part of the country and neglecting the Eastern Corridor which incidentally has the largest population of small ruminants in Ghana. The first phase of the project was to develop improved pastures and feed resources for feeding the animals when they are introduced to the Nkwanta Livestock Station. The pastures were paddocked and fenced. The pasture species established in the first phase were *Cajanus cajan and Gliricidium sepium* for the legumes whilst *Brachiaria brizantha* and *Digitaria decumbens* were cultivated from the grass stock, (for energy provision). Some of the activities carried out included the assessment of the area that needed fencing, the quantity of fencing materials required, labour, , evaluation of alternative short-term materials, cost to complete fencing, assessment of the integrity of the paddocked fields and and the assessment of the Station for any available land for further paddocking or pasture development. Technical reports on the infrastructural challenges as well as all that would get the Nkwanta livestock station back to operational and functional status were prepared and inplemented. In all, 16 acres of pasture fields comprising about 8.5 acres of *Cajanus cajan,* 3.5 acres of *Gliricidia sepium,* 2 acres of *Digitaria decumbens* and 2 acres of *Brachiaria brizantha* were established. Repairs of fencing around the Station's perimeter using Gliricidia live fencing materials was also established and completed. Reinforcement of fencing integrities of three paddocks was completed. Harvesting and conservation of established forages started and is still in progress. Monitoring and evaluation of research activities at the station through regular visits, transfer of essential germplasm and other materials from Accra to the station to support activities are still on-going.

Work on the pasture establishment at the Nkwanta Livestock station is progressing as planned. The next phase of the project activities, which would involve the transfer of the new breed of sheep to the station requires good housing facilities. However, Modernizing Agriculture in Ghana (MAG) funding policy restricts infrastructural development. Without good housing facilities, controlled breeding would be difficult to enforce and hence jeopardize the whole objective of the project. Innovative ways would have to be found to develop the required housing to support the project.


Fig. 1. Land preparation


Fig. 2. Fencing in paddocks


Fig. 3. Established Cajanus field

Genetic selection in Canadian dairy herds

B. A. Hagan, J. Moro-Mendez and R. I. Cue

Animal producers need to select superior animals for breeding so as to improve their herds' performance and that of the entire population. Genetic improvement is driven by four pathways namely sire-to-bull (SB), dam-to-bull (DB), sire-to-cow (SC) and lastly dam-to-cow (DC) as proposed by Rendell and Robertson (1950). These pathways are controlled by artificial insemination centres (SB and DB) and dairy producers (SC and DC). Genetic trends have been the main tool used by most national breeding programs to monitor genetic progress for economically important traits. There are no tools available to individual producers to monitor the amount of selection they are making for economic traits and this will likely have adverse influence on the genetic progress being made in individual herds. The objectives of this project were to (i) define and determine realized genetic selection differentials (GSD) of 28 economically important traits in all four pathways of selection in four dairy cattle breeds in Canada and (ii) develop a prototype software tool and visualization model to assist producers in monitoring the selection on their individual farm, and to compare their farm results with suitable benchmarks.
A number of benchmark GSDs were established from which dairy producers and AI centres could compare their realised and applied selection with.

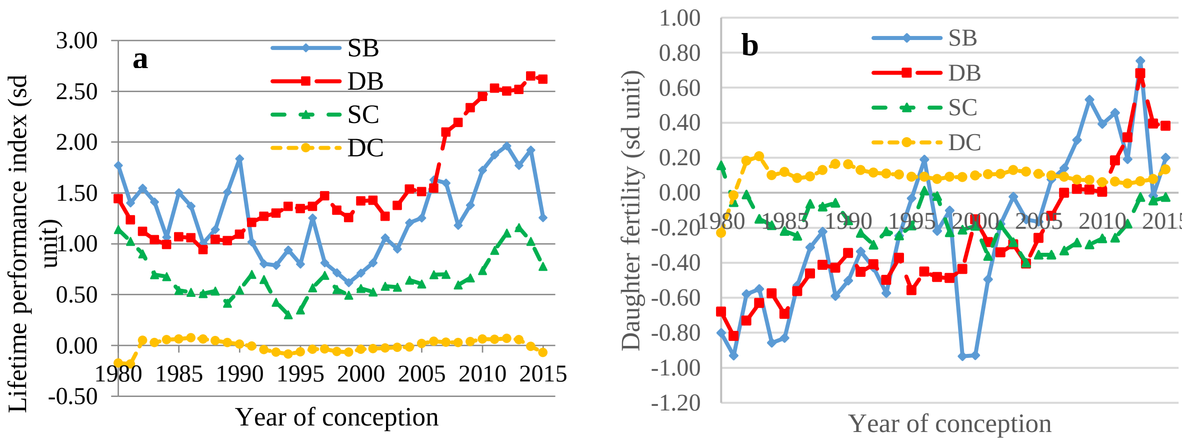

Fig. 1a-b. Mean realized genetic selection differential (in standard deviation unit) per year of conception for (a) lifetime performance index and (b) daughter fertility in the sire-bull, dam-bull, sire-cow and dam-cow pathways of the Holstein breed**.** It was observed that variations exist among herds in their realized GSD for economically important traits. Most non-genetic factors were not important in the selection applied for economic traits. A prototype software has been developed for dairy producers to monitor and visualize selection they are making in their herds and compare them with defined benchmarks. The concept of the prototype software is equally applicable to other livestock species for which genetic evaluations are computed and published. The prototype software has been developed using SAS due to its Rapid Application Development (RAD); it is being translated to Open Source tools (R, Fortran, Linux system, awk). The developed software tool is updatable every time a new genetic evaluation is realized.

Developing climate-smart multispecies fodder bank for increased goat production and income generation in northern Ghana

F. K. Avornyo, R. B. Zougmore, E. K. Panyan and M. T. Shaibu

This study sought to establish multi-species fodder bank including fortification of the fencing area and protection by re-demarcation of fire belt**,** monitor productivity of the various cultivated species in the fodder bank and also evaluate the economics of establishing a multi-species fodder bank**.** One hectare (ha) of multi-species fodder bank containing stands of highly ranked fodder species namely five browse tree species (*Pterocarpus erinaceus*, *Afzelia africana*, *Faidherbia albida*, *Ficus gnaphalocarpa* and *Khaya senegalensis*), three woody legume species (*Cajanus cajan*, *Moringa oleifera* and Lucaena leucocephala), two herbaceous legume species (*Lablab purpureus* and *Stylosanthes hamata*), one fodder grass (Sorghum almum) and two food-feed crops (sweet potato and cassava) and fenced all round were maintained. First, there was community re-entry, review of previous activities and planning of new activities for the rest of 2019 calendar year and beyond. The one ha plot was weeded and trees trimmed. The access road was cleared and fire belt properly marked. The wire fencing was reinforced by the planting of *Bauhinia rufescens* and Jatropha sp. as live fence on the borders of the 1 ha plot. There was replanting (beating-up) of species which did not survive during the 2018 planting season. At the community re-entry meeting, the idea of family or communal ownership of the fodder bank was mooted for resolution. The practice of trading one's labour for fodder bank products was suggested for consideration. Throughout the project span, the climate smart villages (CSV) members were facilitated to do an environmental scan as well as develop an action plan that would help them realize the vision of sustaining the multi-species fodder bank.

During the monitoring and evaluation visit, we expected to identify 14 fodder species but we identified 18 fodder species and two plant species used as live fence. Many *Lucaena leucocephala* plants had fruited and their pods were in the process of drying up indicating that there will be more planting materials next year. *Cajanus cajan* plants were also in the process of flowering and we expect to harvest seeds next year. *Stylosanthes hamata* was the most successful of all the fodder species cultivated. They had grown into a dense mass with numerous seeds. Even though they had originally occupied about 50% of the 1 ha land space they had spread to cover about 75% of the land area and were still spreading. as at the time of assessment

Jatropha cuttings had been planted around the one ha perimeter plot and they were all found to be alive. In addition to the species which were planted to generate fodder for goats in the community, other valuable fodder species were also found in the fodder bank. They were *Sclerocarya birrea* (kontie), *Andropogon gayanus* (songmie), *Spondias mombin* (bunununa/busina) and *Dichrostachys glomerata* (Susule). *Dichrostachys glomerata* in particular appeared to be a climate-smart fodder sp. as it appeared to be colonizing the area at a fast rate. With *Leucaena leucocephala*, *Moringa oleifera*, *Cajanus cajan*, *Stylosanthes hamata, Sorghum almum*, *Andropogon gayanus*, *Sclerocarya birrea*, *Spondias mombin* and *Dichrostachys glomerata* gone past the stage of harvesting, it can be said that the fodder bank became operational at 12 months and planting materials could be obtained from *Leucaena leucocephala*, *Cajanus cajan*, *Stylosanthes hamata*, *Sorghum almum* and *Andropogon gayanus*.

A qualitative assessment of the cost-benefit of the fodder bank development concludes that the benefits outweigh the costs for the following reasons;

i. the fodder bank establishment will improve the visibility of the community and the Lawra municipality as a whole. This can lure other Non-Governmental Organizations (NGOs) to work with us.
ii. There will be increased availability and species of feed value for the animals. The fodder trees, in particular, will continue to exist long into the future, and would be harvested to feed the animals every year.
iii. Income could be generated through the sale of fodder seeds and fodder as feed.
iv. Indirect benefits include the regeneration of economic trees (e.g. shea trees) and medicinal plants that are used to cure snake bite which would have been lost to the annual bush fires

 **Picture 1: Selection of Fodder Bank Management Committee Members**	 **Picture 2: Committee Members Weeding Inside the Fodder Bank**
 **Picture 3: Committee Members Creating Fire Belt around the Fodder Bank**	 **Picture 4: Jatropha sp. planted around the Fodder Bank**

Generally, the 18 fodder species in the fodder bank were fully established. In addition, some farmers who took some of the seedlings home and planted on their individual plots have additional feed as well as propagules. The biggest threat to the fodder bank is the incidence of bush fires despite the creation of a fire belt. An info note would be prepared on highly ranked fodder tree/shrub species in northern Ghana. It would contain information on the nutrient profiles of five most highly ranked browse species, their preference and digestibility characteristics.

The impact of long-term tropical grassland conversion on soil quality and soil carbon stocks

J. K. Nyameasem, C. Malisch , T. Reinsch, C. Y. F. Domozoro, I. Emadodin, E. Marfo-Ahenkora and F. Taube

Enhancing the capacity of livestock systems to sequester carbon is an important measure to tackle soil degradation and climate change. This study evaluated the impact of different long-term land-use scenarios on soil carbon storage and ascertained the impact of condensed tannins (CT) and soil chemical properties on soil C dynamics in grasslands of southern Ghana. Soil samples were taken (0 – 30 cm depth) from 50 years old food crop fields, seeded grazing fields, monoculture fields of fodder grass, legume herbs, legume browse, non-legume browse species and native grassland. CT concentration in the forages ranged from 4 – 67 mg/kg dry matter and were higher ($p < 0.01$) in browses compared to herbs. Nitrogen (N) levels were highly correlated with soil carbon stocks and were significantly higher ($p<0.01$) for fodder grass fields and legume herbs fields. C:N ratio in soils was not significantly affected by the land use system ($p > 0.05$). Plant available phosphorus and potassium represented highest ($p < 0.01$) values in food crop fields. Soil pH varied only with a significant rate ($p < 0.001$) between food crop fields and seeded gazing fields. Soil carbon stocks ranged from 16.6 — 64.1 t C ha-1 (mean ± s.e: 33.1 ± 1.13 t C ha-1) across land use systems and were lower ($p < 0.01$) for grazed seeded-pasture fields and herbaceous legume plots compared to the other land use systems. Conversion of the natural grassland resulted in a mean loss of 480 kg C ha^{-1} $year^{-1}$. There was significant ($p < 0.05$) positive correlation between the long-term changes in soil C stock and CT fractions ($r = 0.33$–0.49). Also, correlation tests showed positive relationships between change in soil C-stock and soil chemical traits ($r = 0.043$–0.91). The current case study indicated that a multiple linear regression equation with N, CN and K as principal factors could explain 98% of the long-term changes in SOC stock.

Intensification of integrated crop-livestock systems in northern Ghana for sustainable increase in smallholder farm productivity: Strengthening of small ruminant value chains

F. Avornyo, A. Ayantunde, E. Panyan and M. Shaibu

The study was conducted to increase small ruminant value chain input and output services and to improve the technical, organizational and managerial capacities of small ruminant value chain actors in northern Ghana. A baseline survey was conducted in two intervention districts. The baseline information included the level of organization of existing small ruminant value chain, level of adoption of proven technologies by actors as well as linkages to other actors and markets. A visit was paid by a core team of researchers to Burkina Faso to gain an understanding of how they have developed their small ruminant value chain with a view to adopting best practices. Through the project implementation, a number of challenges and best practices have been identified for recommendation and attention in order to revive the small ruminant value chain in Ghana.

The implementation team was also able to map out the small ruminant trade routes that pass through the project sites namely Wa and Navrongo. A number of best practices for effective performance of the small ruminant chain were also identified. A visit to Ouagadougou showed that there was intense governmental involvement in the livestock sector in Burkina Faso coupled with remarkable research component. It was also realized that there was noticeable and well-intentioned heavy animal protein consumption. Further, livestock was taken more as a business in Burkina Faso than in Ghana and livestock feed production/technology was taken seriously. The project team is in the process of screening small ruminant actors and stakeholders who will represent various actor groups on a proposed Innovation Platform to strengthen the value chain.

Fig. 1. Small ruminant market in Ouagadougou,Burkina Faso

Fig. 2. Animal feed in sacks, small ruminant market in Ouagadougou, Burkina Faso

Fig. 3. Water supplier ready to move to the next caller, small ruminant market in Ouagadougou, Burkina Faso

Insects as Feed for West Africa (IFWA)

E. K. Nkegbe, S. Affedzie-Obresi, G. A. Aboagye and P. A. Wallace

The insect as feed project aims at sustainable use of housefly larvae, black soldier fly and termites as poultry feed and/or alternative source of protein in place of fishmeal in smallholder farms. It seeks to investigate the health implication of the use of housefly larvae, black soldier fly larvae and termites as poultry feed, their nutritional efficacies as well their socio-economic effects. This aspect of the study focused on assessesing the effect of insect protein intake during the pullet – to – breeder transition on egg production. In all, 360 pullets and 36 cockerels were selected at 10 weeks of age, reared separately till 16 weeks and grouped at the ratio of one cockerel to ten pullets. The design of the experiment was as follows: 20 pullets X 3 replicates X 6 dietary treatments. The six dietary treatments (source of protein) were soybean meal, fishmeal, insect larvae meal, soybean plus fishmeal, soybean plus insect larvae meal, soybean meal plus fishmeal plus insect larvae meal. The study is still at its inception stage and the following have so far been done the production of insect larvae meal as protein substitute, organization of stakeholders-policyimplementers workshop using the Research-Extension-Linkage Committee (RELC) platform to discuss and demonstrate the practical and commercial use of insect larvae meal as protein substitute in poultry feed, monitoring of project activities being undertaken in the Northern, Upper West, Upper East, North East and Volta Regions among others. Feeding trials on quails using insect larvae as source of protein is still being conducted. Routine activities at the project site will continue and information dissemination platforms will be used to provide the necessary information on the progress of the project.

Developing a Simple, Cheap, Safe but Effective Technology for Handling and Processing Hatchery Wastes for incorporation into Rations for Pigs

P. Asiedu, P. A. Wallace , A. A. Prah, F. N. A. Odoi, C. T. Arthur and D. Y. Osei

Raw hatchery waste comprising infertile eggs, egg shell, dead-in-shell and low-grade unsalable chicks were subjected to three different processing protocols . The well sorted hatchery wastes were processed by steaming in a covered steel drum for periods of (i) 5 (ii) 10 or (iii) 15 minutes, in order to cook and also sterilize them. All the samples were then dried in a hot air oven, at three different temperatures and duration: (i) 60 ^{o}C for 48 hrs, (ii) 70 ^{o}C for 36 hrs, and (iii) 80 ^{o}C for 24 hrs All sub-samples were subjected to proximate analyses and microbial evaluation. The results of the proximate composition showed that the hatchery waste meal (HWM) is rich in protein, ash, dry matter and fat. The percentage residual crude protein (CP) content in the differently processed HWM samples were 44.71% (5M60T), 38.57% (5M70T), 49.90% (5M80T), 48.82% (10M60T), 38.41% (10M70T), 46.24% (10M80T), 47.81% (15M60T), 38.26% (15M70T) and 45.63% (15M80T) respectively. Again, the mean total viable counts for 5M80T, 10M60T, 10M80T, 15M60T, 15M70T and 15M80T were 9.30, 9.80, 9.54, 9.40, 9.95 and 9.98 respectively. In conclusion, it can be conveniently inferred that hatchery waste meal processed at 5M80T would not only be proteinaceous but have comparatively best microbial load reduction effect.

BIOMEDICAL AND PUBLIC HEALTH: ANIMAL HEALTH AND BIOSAFETY

Effect of animal trypanosomes and tick-borne parasites co-infection on cattle immunity

J. A. Ofori, P. A. Wallace, T. Manful Gwira, K. Boateng Yeboah, M. E. Shiburah, C. Kusi, K. Owusu Ansah and J. Beyuo

In natural populations, animals may be infected with multiple but distinct pathogens at a time leading to the existence of co-infections. Different parasites induce quite different immune responses; the immune response to protozoans is strongly towards T helper 1 cells (Th1), whilst helminths are strong towards Th2 and regulatory T cell inducers [12]. The question of how the co-existence of different parasites within the same animal host might influence the host immunological environment especially the cytokine profile still needs to be addressed. More importantly, whether such interactions affect resistance, susceptibility or disease pathogenesis needs to be investigated.

The study assesses animal African trypanosomes and tick-borne parasites co-infection prevalence in cattle at different ecological zones in Greater Accra region, Ghana and the effect of co-infections on animal cytokine production and haematological profile.This longitudinal study will be carried out at CSIR-ARI farms (Katamanso and Pokuase Stations) in Greater Accra region using a total of 40 cattle aged between 6 months and 1 year. Twenty (20) cattle each from the two separate study sites will be used. Blood will be taken at monthly intervals over the 6 month period. DNA will be extracted to characterize the trypanosomes and tick-borne pathogens in the cattle using molecular techniques. Blood will also be drawn for haematological assay using an automated haematology analyzer. In addition, sera will be prepared to determine the cytokine profile.

Two herds of cattle have been identified for the study. The first herd is at the CSIR-ARI Katamanso station which has a coastal savanna vegetation. The herds there are Sanga and Sanga cross (Fig. 1A). The second herd is on a cattle farm located at CSIR-ARI Pokuase station (coastal savanna- forest transition zone). N'dama cattle are the only breed type found at the Pokuase station (Fig. 2A). The key points are that at both locations:

(i) the herds are large and contain sufficient number of younger animals that could be followed for the duration of the proposed study (Fig. 1A and 2A)

(ii) 20 young cattle are available in each herd and have been ear tagged (Fig. 1 and 2) and will be followed for the 6 months of the study period

(iii) with the presence of a stationed technical team and registered Veterinarian at CSIR-ARI, there is guaranteed access and assistance to obtain the blood samples each month (Fig. 1B and 2B)

(iv) the cattle may have to be treated routinely (but this will be recorded and may provide additional data)

(v) records of age, sex, breed and body condition score of the individual cattle at the study sites will be documented. Cattle selection and tagging at both CSIR-ARI Katamanso and Pokuase farms were successfully executed and are kept at the various farms to be used for further research after the ethical approval is issued.

A B

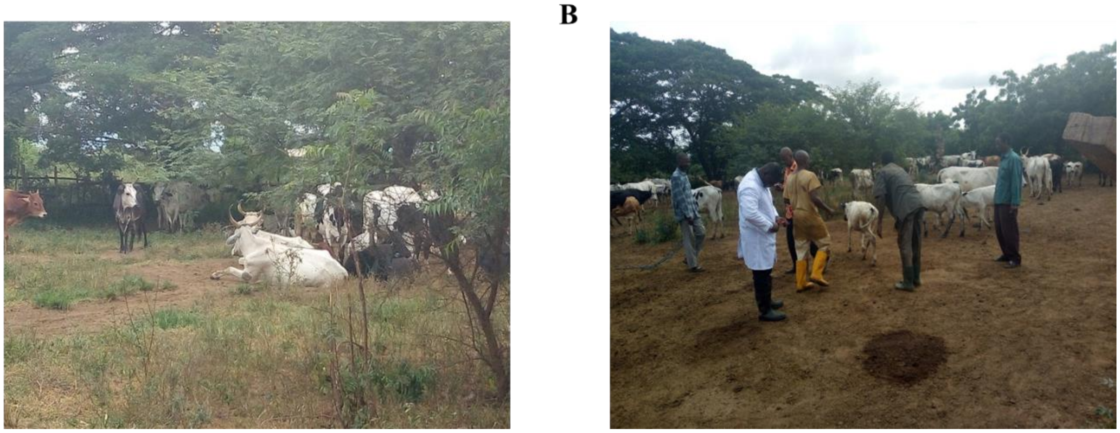

Fig. 1: Selection and tagging of cattle at Katamanso station farm, CSIR-Animal Research Institute. A) Available breed cattle are Sanga and Sanga Cross. B) Technical and non-technical teams

A B

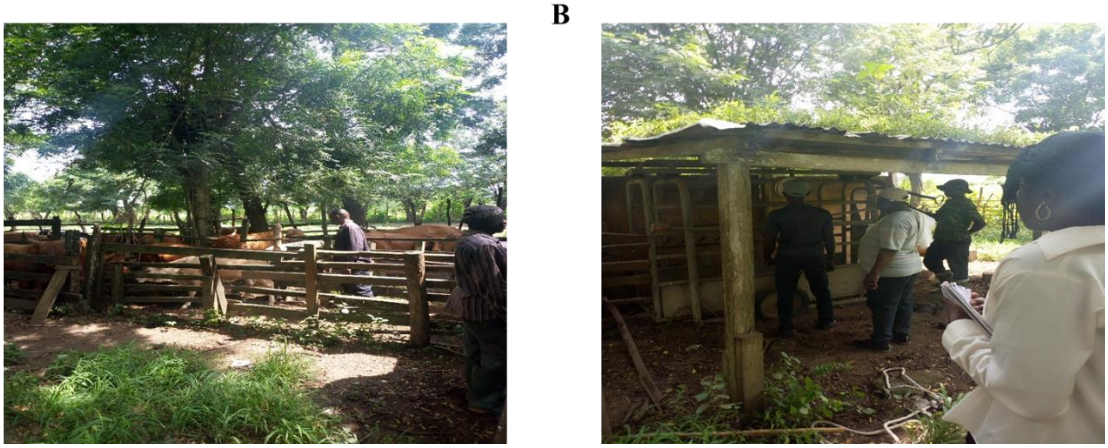

Fig. 2: Selection and tagging of cattle at Pokuase station farm, CSIR-Animal Research Institute. A) Available breed cattle is N'dama. B) Technical and non-technical teams.

***Campylobacte*r in retail chicken in Accra, Ghana: Integrating microbiological evidence and probabilistic modelling toward quantitative risk assessment of human food-borne illnesses**

N. Owiredu, C. Arthur, F. Nathan-Mensah, L. Agbomegah and R. Ohene-Larbi

Food-borne illnesses are a major cause of morbidity and mortality all over the world. According to the World Health Organization Global Burden on the estimate of F food-borne diseases, 31 food-borne hazards caused 600 million food-borne illnesses and 420,000 deaths in 2010 with diarrhoeal disease agents particularly *Norovirus* and *Campylobacter* being the most frequent. Though poultry is widely consumed in Ghana, it is reportedly the primary reservoir of *Campylobacter* and that raw poultry easily gets contaminated with *Campylobacter*. The study, therefore, undertook a prevalence survey of *Campylobacter* in retailed chicken as well as a consumer survey using a risk assessment approach. Data obtained would be subsequently used for risk modeling as the study progresses. Baseline data on the prevalence and quantitative counts of *Campylobacter* in retailed chicken in Accra, Ghana would be generated and statistically analyzed. Sampling and isolation of *Campylobacter* from fresh as well as retailed chicken purchased from the open markets and supermarkets in the Greater Accra Metropolitan Area were carried out. The isolation was conducted ut in the Microbiology laboratory of the CSIR-Animal Research Institute using ISO 10272 protocol for *Campylobacter*. Isolates were confirmed by MALDI-TOF at the Noguchi Memorial Institute for Medical Research – University of Ghana. A consumer survey was undertaken on the purchase, handling and consumption of retailed fresh chicken from the risk assessment point of view. 395 consumers were interviewed and data obtained has been captured in CSPro. Data obtained so far would be analysed with STATA.

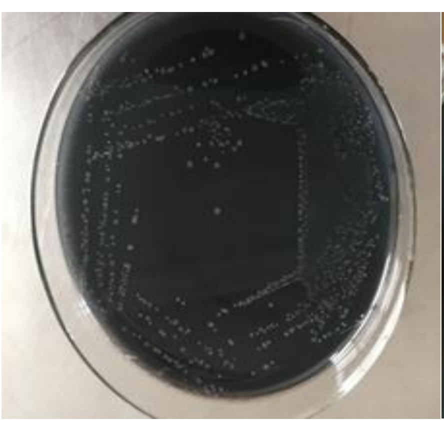

Fig. 1

Fig. 2

Fig. 3

Fig. 1. Data analysis *Fig. 4 Chicken from supermarket (left) and wet market (right)*
Fig. 3: Dressed chicken on display at Nungua market

Epidemiology of Influenza A viruses in poultry and pigs and their handlers in Ghana

M. Ayim-Akonor

Influenza A viruses (AIVs) occurs worldwide and affects several avian and mammalian species. The virus is classified into sub-types based on the haemagglutination (HA) and neuraminidase (NA) surface glycoproteins of which 16 HAs and 9 NAs circulate in wild birds (the natural reservoirs) and are occasionally transmitted to terrestrial animals. IAVs undergo host restriction barriers but interspecies transmission with various sequale can occur. Globally, there is an increase in human infections with IAVs and livestock farmers are among those at thehigh risk group. In Ghana, there is little information on the ecology of influenza infections in poultry and pigs and much less of farmers who are in regular contact with these animals. The project objectives are to determine IAVs circulating among poultry and pigs and their farmers in the Ashanti region of Ghana and to genetically characterize these viruses. During the reporting period, laboratory analysis of viral isolation, identification and full genome sequencing of the eight gene segments of all IAVs identified were performed. Serological analyses were also performed on all the animal and human sera. IAV was detected in poultry at a molecular and serological prevalence of 0.2% and 0% respectively. Two farmers (2.0%) tested positive to human seasonal IAV H1N1pdm09. Sixteen (15.7%) farmers tested seropositive to IAV of which 68.8% (n=11) were due to H1N1pdm09-specific antibodies. AIV H5- or H7-specific antibodies were not detected in the farmers. In pigs, all the 17 IAVs identified were sub-typed as H1N1pdm09. Phylogenetically, these viruses were closely related to H1N1pdm09 viruses that circulated among humans in Ghana in 2016 and 2017 but highly distant from all the H1N1pdm09 viruses identified in pigs in Africa deposited in GISAID database. Pig farmers were infected and exposed to human IAVs of H1N1pdm09 and H3 only. IAV was not endemic in the Ashanti region but sporadically transmitted during our sampling period (2016-2017). Pigs in the region are infected with human-like influenza viruses but not pig origin IAVs. There is the need to educate farmers on biosafety measures to reduce the incidence of reverse zoonoses. Regular surveillance among pigs in the region should be undertaken to monitor viral genetic changes and furthermore assess the potential risk to humans.

Development of treatment schedule for the control of Emeria infestation in rabbits in Ghana

S. Affedzie-Obresi, D. Owusu-Ntumy, D. Osei, N. Owiredu, J. Beyuo, K. Yeboah Boateng and B. Bortieh.

Rabbit production is growing in Ghana and the industry is vulnerable to the spread of coccidiosis. However, fewer studies have been conducted in relation to the control strategies for coccidiosis in rabbit in Ghana. Farmers have reported increased bunny mortalities and in all situations, coccidiosis was on top of the suspected causes. A prevalence study was, therefore, conducted and treatment schedules advanced for trials on selected farms. Inception meetings were held with livestock officers and farmers in the Ga East, Ga South and Ga Central Districts (Fig. 1). Selected farms were visited for sampling (Fig. 2). Laboratory analysis of rabbit faecal samples collected from twelve rabbit farms (four farms per district) across the three districts in the Greater Accra region were conducted. CSIR-ARI Katamanso station rabbit farm serves as the control. Analyses of samples are still on-going.

Fig. 1. Inception workshop

Fig. 2. Taking rabbit faecal samples

Epidemiological survey of guinea fowl (*Numida meleagris*) keet mortalities

M. Ahiagbe, F. Avornyo, S. Salifu and E. Allegye-Cudjoe

Growing keet mortalities in guinea fowl has been observed in communities in Northern Ghana and Volta Regions. Studies were conducted to ascertain exact causes of keet mortalities through post-mortem and microbial analysis. Visits to the Northern, Upper East and the Volta Regions were conducted to collect baseline data on husbandry practices, breeder stock management, feeding and health management practices through structured questionnaires from participating guinea fowl farmers. Dead carcass of the keets were collected and post-mortem were carried out. Samples from brain, viscera and intestine were collected for each dead carcass sample and were transported to Accra for further analysis. The majority (64%) of birds exhibited signs of anaemia. Observations by farmers before the mortalities included nervous like symptoms, loss of appetite and weakness although. Laboratory analysis is currently underway to ascertain associations between farmer practices and incidence of major poultry diseases. As at the stage of this study we can conclude that the nutrition status of keets need to be improved by both improving maternal nutrition and feeding during brooding period.

SCIENCE AND PEOPLE: TECHNOLOGY FOR LIVELIHOOD & WEALTH CREATION, VALUE CHAIN PROMOTION

Establishment of Small-Scale Commercial Layer Model

V. K. Lamptey, A. A. Koranteng, G. Adu-Aboagye, K. Owusu Amoah, E. K Adu and K. Boa-Amponsem

The project sought to strengthen the self-financing capacity of small scale farmers through the retention of project earnings as well as build the capacity of experts in member countries through co-operation with Korean experts. 17-week-old pullets raised on the CSIR-ARI Research farm were distributed to six beneficiary farmers that were selected based on recommendations from the then, La Nkwantanang MoFA Directorate in consultation with the Korea-Africa Food and Agriculture Cooperation Initiative (KAFACI) team . Four of these farmers were assisted to upgrade the infrastructure of their farms while the rest (two) were not. The layers on the farmers' farms are presently 61 weeks old and their laying performance is being monitored by the farmers as well as the KAFACI team. Two of the farmers prepare their own feed, two buy commercially-made feed from the market whiles the other two buy feed from CSIR-ARI. Currently, the hens are laying between 50 and 80% on the various farms. The project team continued with their routine visit to the farms. The beneficiary farmers as well as other farmers from the Adenta Municipality were trained by the KAFACI project on the following underlisted topics:

- Poultry biosecurity and vaccination schedule
- Farm record keeping and analysis
- Feed formulation
- Challenged feeding
- Ingredient identification and feed formulation (practical session)

Fig. 1. Training sessions at CSIR-Animal Research Institute

Fig. 2. Beneficiaries of training sessions identifying feed ingredients at Calebeg feed mill

Fig. 3. Exposure and demonstration of feed milling and mixing enterprise

Outcomes of the Training

- Farmers ensure proper biosecurity measures and are adhering to proper management practices
- Farmers have now acquired more knowledge relative to the nutrient requirement of layers during their developmental stages
- Farmers are well-informed on the storage and mode of application of drugs usually used on poultry farms
- Some beneficiary farmers employed some youth within their communities
- There is the availability of table eggs in the neighborhood of beneficiary farmers
- Most of the farmers have seen an increment in their profit margins which has positively influenced their livelihood
- The beneficiary farmers are able to raise dayoldchicks through pullet stage and finally to the laying stage using standard protocols they learnt during the KAFACI trainings sessions
- Most of the beneficiary farmers did some expansion on their farms

Table 1. Productivity of the selected farms for the project period

	Name of Farms					
Production Parameters	**Swinton Farm**	**Magi Farm**	**Magsan Farm**	**TAC Farm**	**Adobea Farm**	**Doris Farm**
Total eggs laid /Month	3, 584	3, 512	3, 285	3, 906	3, 654	2, 972
Rate of lay (%/Month)	83.83	80.44	81.17	73.73	84.26	80.49
Income (GHS / Month)	1,791.75	1,756.00	1,642.65	1,953.15	1,827.05	1,486.2
Income (USD / Month)	358.35	369.68	345.82	411.19	384.64	312.88
Feed & water Cost (GHs/Month)	1,228.78	1,253.30	1,162.36	1,502.36	1,246.20	1,051.30
Feed & water Cost (USD/Month)	245.76	250.66	232.47	300.47	249.24	210.26
Profit (GHs/Month)	562.98	502.70	480.29	450.79	580.85	434.90
Profit (USD/Month)	112.60	100.54	96.06	90.16	116.17	86.98

The KAFACI Project of the Rural Development Administration of South Korea funded this entire initiative. It is recommended that a higher number of small-scale farmers be enrolled to also have the opportunity of being trained in modern layer production to help improve their livelihood. It is further recommended that farmers should be provided with at least 500 pullets in order to increase their production and profit margin.

SUMMARY OF FINANCIAL STATEMENT - 2019

REVENUE	**2019*** **GHc**	**2018** GHc
GoG Grant	10,225,285.77	9,054,999.00
Institutional Support	51,326.67	28,668.00
Total income	**10,276,612.44**	**9,083,667.00**
EXPENDITURE		
Employment cost	10,225,285.77	9,054,999.00
Transport & Traveling cost	46,770.00	89,113.00
Repairs & Maintenance	32,008.07	80,017.00
Financial & professional charges	15,140.64	13,186.00
Depreciation	128,258.40	130,551.00
General Administrative Expenses	73,101.53	126,029.00
TOTAL EXPENSES	**10,520,564.41**	**9,493,895.00**
Excess income over expenditure	(243,951.97)	(410,228.00)
Net income from Internally Generated Fund (IGF)	**215,823.19**	**394,399.00**
Net Deficit for the year	**(28,128.78)**	**(15,829.00)**

INTERNALLY GENERATED FUNDS

Source of funds	**2019*** GHc	**2018** GHc
Income from Farm produce	73,010.80	84,776.00
Hiring of Vehicles	6,940.00	3,550.00
Sale of livestock	34,844.00	15,790.00
Dairy product	14,280.00	60,256.00
Technical services	-	3,530.00
Sheep Blood	22,140.00	17,750.00
Laboratory services	16,350.00	32,640.00
Training services	6,220.00	24,600.00
Vet Clinic proceeds	10,550.00	12,425.00
Interest received	-	197.00
Consultancy fees	900.00	
Research project	8,090.00	2,310.00
Guest House income	21,230.00	26,480.00
Income from CCST	-	10,575.00
Rent income	1,248.00	31,044.00
Other income	-	5,458.00
Hiring of Tractor	1,310.00	11,600.00
TOTAL INCOME	**217,112.80**	**342,981.00**

***Note: This is an unaudited Financial Statement for the year 2019.**

HUMAN RESOURCE ACTIVITIES

Staff Strength

The total number of staff as at December, 2019 was 241. The breakdown is as follows:

Senior Members	-	52
Senior Staff	-	64
Junior staff	-	123
Post-Retirement Contract	-	2

TOTAL		241

Internal Transfers

The following Officers were transferred from other CSIR Institutes to CSIR-ARI :

NAME	FROM	TO
Dr. Ebenezer D. O. Ansa, *Prin. Res. Sci.*	CSIR-Water Research Institute	CSIR-Animal Research Institute
Mrs. Grace A. Oduro, *Chief Tech. Officer*	CSIR-Oil Palm Research Institute	CSIR-Animal Research Institute
Mr. Albert O. Boadu, *Accounting Asst.*	CSIR- Head Office	CSIR-Animal Research Institute

New Appointments

During the year under review, some recruitments were made to augment the Institute's staff strength. The breakdown is as follows:

NAME	DESIGNATION	DATE OF EMPLOYMENT	DIVISION ASSIGNED TO
Dr. Jennifer A. Ofori	Research Scientist	1st April, 2019	Farmed Animal Technology Development Division
Ms. Theresa Nkrumah	Principal Technologist	6th May, 2019	New Products Development, Food Safety & Marketing Division
Ms. Rita Ohene Larbi	Principal Technologist	1st April, 2019	Companion Animals & Livestock Disease Control & Prevention Division
Dr. Boateng K. Yeboah	Principal Technologist	1st April, 2019	Companion Animals & Livestock Disease Control & Prevention Division
Mr. Godson A. Zagbede	Principal Technologist	1st April, 2019	Genomics & Livestock Improvement Division
Mr. Mark Ewusi Shiburah	Technical Officer	11th March, 2019	Genomics & Livestock Improvement Division
Mr. Benjamin Owusu Opoku	Technical Officer	1st April, 2019	Natural Resource Management & Environmental Health Division
Mr. Benard B. Bortei	Principal Technologist	1st April, 2019	Directorate

Retirement

Two senior members, one senior staff and four junior staff retired compulsorily at the age of 60 (sixty) years. The officers were:

Senior Members

NAME	DESIGNATION	DATE OF RETIREMENT
Prof. E. K. Adu	Director	22nd June, 2019
Mr. Tutu Coffie Aikins	Senior Accountant	17th August, 2019

Senior Staff

NAME	DESIGNATION	DATE OF RETIREMENT
Mr. Stephen O. Asante	Asst. Transport Officer	27th January, 2019

Junior Staff

NAME	DESIGNATION	DATE OF RETIREMENT
Mr. Mohammed Ali Nabbah	Security Asst. Gd. I	1st January, 2019
Ms. Peace Kalai	Field Asst. Gd. I	20th February, 2019
Mr. Seth Odamtten	Supervisor Gd. I	1st June, 2019
Mr. Seidu Amadu	Supervisor Stockman	4th August, 2019

Resignations

	NAME OF STAFF	DESIGNATION	DATE OF RESIGNATION
1	Dr. Kodjo Atiso Elolo	Librarian	30th November, 2019
2	Mr. Kwame Dwumah	Chief Tech. Officer	30th November, 2019
3	Mr. Andrews Asante	Senior Tech. Officer	14th April 2019
4	Mr. Amadu Osmanu	Supervisor GD. 1	3rd June 2019

Voluntary Retirement

NAME OF STAFF	DESIGNATION	DATE OF RETIREMENT
Mrs. Lawrencia Botchie	Marketing Officer	30th November, 2019

Promotions/Upgrading

The under-listed staff were promoted during the year:

Senior Members

NAME	PRESENT GRADE	RECOMMENDED GRADE
Mrs. Vida K. Lamptey	Research Scientist	Senior Research Scientist
Mr. John K. Nyameasem	Research Scientist	Senior Research Scientist
Mrs. K. M. J. Ahiagbe	Research Scientist	Senior Research Scientist
Mr. Edward Obiri Yeboah	Chief Accounting Assistant	Accountant
Ms. Gifty Ziema Bumbie	Chief Technical Officer	Prin. Technologist
Mr. Felix Kwesi Hagan	Prin. Administrative Assistant	Administrative Officer

Senior Staff

NAME	FROM	TO
1. Mr. John Nortey	Prin. Stores Superintendent	Chief Stores Superintendent
2. Mr. Eric Nikae-Mensah	Senior Accounting Assistant	Prin. Accounting Assistant
3. Mrs. Eunice Abeiyel Kuor	Senior Accounting Assistant	Prin. Accounting Assistant
4. Ms. Mary Kwadzodza	Senior Accounting Assistant	Prin. Accounting Assistant
5. Mr. Thomas Putier	Senior Accounting Assistant	Prin. Accounting Assistant
6. Irene Ago Adjei	Senior Accounting Assistant	Prin. Accounting Assistant
7. Mrs. Augustina D. Akweshie	Senior Stores Superintendent	Prin. Stores Superintendent

8. Mrs. Antoinette Vordzorgbe	Senior Technical Officer	Principal Technical Officer
9. Mr. Teye Alphonse Pernortey	Senior Technical Officer	Principal Technical Officer
10. Mrs. Diana Narh	Senior Technical Officer	Principal Technical Officer
11. Mrs. Frances N. Nathan-Mensah	Senior Technical Officer	Principal Technical Officer
12. Mr. Leonardo Abormegah	Senior Technical Officer	Principal Technical Officer
13.Mr. Michael Baba Agombire	Senior Technical Officer	Principal Technical Officer

Junior Staff

NAME	FROM	TO
Mr. Fuseni Numo	Senior Technical Assistant	Works Superintendent
Mr. Alfred Puo	Security Assistant Gd. II	Security Assistant Gd. I
Mr. Martin Owusu Antwi	Security Assistant Gd. II	Security Assistant Gd. I
Mr. Bright Ayitey Quaye	Security Assistant Gd. II	Security Assistant Gd. I
Mr. David Narh	Security Assistant Gd. II	Security Assistant Gd. I
Mr. Dennis Akwasi Debrah	Security Assistant Gd. II	Security Assistant Gd. I
Mr. Emmanuel Tsengei	Security Assistant Gd. II	Security Assistant Gd. I
Mr. Isaac Dotse Kudjordjie	Security Assistant Gd. II	Security Assistant Gd. I
Mr. Vincent Serwonu	Security Assistant Gd. II	Security Assistant Gd. I
Mr. Joseph Kumedzro	Security Assistant Gd. II	Security Assistant Gd. I
Mr. Emmanuel Opoku	Tractor Operator Gd. I	Crawler Tractor Operator
Mr. Raphael Agbenyenu	Tradesman Gd. II	Artisan
Mr. Janard Joseph Marfo	Driver Inspector	Traffic Supervisor
Mr. Ernest Martey	Driver Inspector	Traffic Supervisor

PUBLICATIONS

1. Affedzie-Obresi, S., Adu – Aboagye, G., Nkegbe, E. K., Asuming – Bediako, N., Ansah, K. O., Mensah-Bonsu, A., Sarpong, D. B., Amegashie, D. P. K., Kwadzo, G. T-M., Wallace, P. A and Clottey, V. A. (2019). Black Soldier Fly (*Hermitia illucens*) Larvae Meal as Alternative Protein in Broiler Production in Ghana. *Ghana Journal of Agricultural Science* (Accepted for publication).

2. Avornyo, F. K., Partey, S. T., Zougmore, R. B., Asare, S. Agbolosu, A. A., Akufo N. M., Sowah N. A., Konlan S. P. (2019). *In vivo* digestibility of six selected fodder species by goats in northern Ghana. *Tropical Animal Health and Production* https://doi.org/10.1007/s11250-019-01989

3. Ansah, J. W. and Takyiakwaa, D. (2018). Civil Society Engagement in Ghana's Public-Private Partnership Regime: A Case Study of IMANI and Ghana Integrity Initiative (GII). *Ghana Social Science Journal,* Vol. 15 (1), 30-64.

4. Asuming-Bediako, N., Kunadu Parry-Hanson, A., Abraham, S. and Habib I. (2019). *Campylobacter* at the Human–Food Interface: The African Perspective, *Pathogens*, 8, (87)

5. Ayim-Akonor, M. , May J. , Ralf K. , Harder T. and Mertens E. (2019). Molecular and se rological prevalence of influenza A viruses in poultry and poultry farmers in the Ashanti re gion, Ghana. *Infection Ecology & Epidemiology*, 9:1

6. Boateng, M., Okai, D. B., Amoah, K. O., Opoku-Asenso, A., Aye, K. A. and Frimpong, Y. O. (2019). Cocoa placenta meal: Yield estimates, nutrient composition and response of al bino rats to diets containing graded levels with or without Xzyme TM an exogenous enzy me- probiotic complex. *Bulletin of Animal Health and Production in Africa*, 67, 141-150

7. Boafo, H. A. , S. Affedzie-Obresi, D. S. J. C. Gbemavo, V. A. Clottey, E. Nkegbe, G. Adu-Aboagye and Marc Kenis (2019). Use of Termites by Farmers as Poultry Feed in Ghana. *Insects* 10:69

8. Konlan, S.P., Salifu **. S**. and Tiyumtaba S. M., (2019). Effect of Groundnut Haulms and Maize Bran Supplementation on Growth Performance and Estimated Market Value of Djallonke Sheep under Smallholder Production Systems. *Ghanaian Journal of Animal Science*, 9 (2):73-80

9. Nkegbe, E. K., Adu-Aboagye, G., Afedzie-Obresi, S., Boafo, H. A., Wallace, P., Clottey, V., Kenis, M., Nacambo, S., Karbo, N. and Aning, G. K. (2019) Chemical safety of biological substrates and their contamination factors associated with housefly larvae meal. *Ghanaian Journal of Animal Science* 9. (2): 148-151

10. Nkegbe, E. K., Arwo, B. H., Adu-Aboagye, G., Afedzie-Obresi, S., Wallace, P., Karbo, N., Clottey, V., Nacambo, S., Kenis, M. and Aning, G. K. (2019) Microbial isolates associated with potential housefly larvae meal production substrates in Southern Ghana. *Ghanaian Journal of Animal Science* 9 (2): 135-140

11. Nkegbe, E. K., Adu-Aboagye, G., Affedzie-Obresi, S., Wallace, P., Arwo Boafo, H., Clottey, V., Nacambo, S., Kenis, M., Karbo, N., and Aning, G. K. (2019) Effects of housefly larvae meal on blood cells, serum electrolytes and biochemical parameters of grower phase indigenous coastal savannah ecotype chicken in Southern Ghana. *Ghanaian Journal of Animal Science* 9 (2): 33-38

12. Squire, S. A., Robertson, I. D., Yang, R., Ayi, I. and Ryan, U. (2019). Prevalence and risk factors associated with gastrointestinal parasites in ruminant livestock in the Coastal Savannah zone of Ghana. *Acta Tropica,* 199: 105126. https://doi.org/10.1016/j.actatropica.2019.105126

13. Takyiakwaa, D. (2019). Social Networks in Urban Situations: Analyses of Personal Relationships in Central African Towns. Edited by J. Clyde Mitchell, *Migration Studies*, 7(3):384–386.

14. Takyiakwaa, D**.** and Tanle, A. (2019). 'We are each other's keeper': Migrant Associations and Integration in Urban Africa. *Urban Forum,* DOI: https://doi.org/10.1007/s12132-019-09373-5

TECHNICAL REPORTS

1. Aboagye, G. A., Vida Lamptey and Achiamaa A. K (2019) Development and Application of Management Techniques for non-ruminant Livestock. Presented to KAFACI Secretariat
2. Aboagye, G. A., Takyiakwaa, D., Adu, E. K and Wallace, P. A. (2019). Trsnsformation of Gray Farms through the intervention and technology transfer impact of CSIR-Animal Research Institute. Gray Farms, Fiankonya, Greater-Accra Region
3. Amankwa, K., Kotoe, L., Appoh, E., Essel, D., Sackey, B., Benefoh, D. T., Addo, S., Dzo bo, M., Amoah, S., Quansah, E. O., Baffoe, J., Kwakye, M. O., Nerquaye-Tetteh, E., Foli, E., Amoako, K., Flafe, C., Amoako, J., Yakubu, M., Baffoe, K. A., Domozoro, C., Asante, W. A., Asubonteng, K. O., Mensah, F., Fredua, K. B., Ottou, R., Bempah, J., Baffoe, J. Ro ckson, G., Hesse-Ankoma, J. and Lamptey, D. A. (2019). Ghana's Fourth National Green house Gas Inventory Report. Report National Greenhouse Gas Inventory to the United

Nations Framework Convention on Climate Change (Accra, Ghana).

4. Ayantunde, A., Salifu S, Konlan S. P. and Tiyumtaba S. M. (2019). Efficient feed utilization through improved feed troughs for small ruminants in Northern Ghana. Africa Rising Technical Report submitted to IITA.
5. Affedzie-Obresi, S., Antwi, C., Eddico, P. and Adu, E. K. (2019). Mushroom Production and Marketing in Ghana
6. Affedzie-Obresi, S., Antwi, C., Eddico, P and Adu, E. K. (2019). Market Survey on Egg Marketing in Cocoa Growing areas of the Ashanti and Western North Regions of Ghana
7. Karbo, N., V. A. Botchway, K. O. Sam (2019). National stakeholders' workshop of the Ghana national science-policy dialogue platform on climate change, agriculture and food security.

CONFERENCE/WORKSHOP

1. Ahiagbe, K. M. J., Amuzu-Aweh, E. N., Avornyo, F. K., Adenyo, C., Nyameasem, J. K., Bonney, P., Amoah, K. O., Naazie, A. and Kayang, B. B. (2019). Comparison of early growth and survivability in indigenous guinea fowls from Northern Ghana. *Proceedings of 7th All Africa Conference on Animal Agriculture,* Accra*,* Ghana, 85.

2. Asiedu, P, Odoi F. N. A, Wallace P, Prah A. A and Bumbie G. Z 2019. Impart of Hatchery Waste Meal on Growth performance, Carcass and Cost-Benefits Analysis of Grower-Finisher pigs. 8th Asan-Nias Joint Annual Meeting (Jam) /International Conference, September 8-12, 2019. Pp 187-189

3. Marfo-Ahenkora, E**.,** Taah, K. J., Asare-Bediako, E., Munkaila, L., Ameleke, G. Y. and Domozoro, C. Y. F. 2019. Factors Influencing uptake of sustainable production practices of maize in smallholder farming systems at the semi-deciduous forest and coastal savannah agro-ecological zones of Ghana. 31st Biennial Conference of the Ghana Science Association Programme and Book of Abstracts. University of Cape Coast, Cape Coast. Theme of Conference??? Editors of Conference??? Date of Conference???

4. Marfo-Ahenkora, E**.,** Ameleke, G. Y., Taah, K. J. and Asare-Bediako, E., 2019. The impact on profit from changes in maize varieties and soil amendments in smallholder environments in the semi-deciduous forest and coastal savannah agro-ecological zones of Ghana. 31st Biennial Conference of the Ghana Science Association Programme and Book of Abstracts. University of Cape Coast, Cape Coast. Theme of Conference??? Editors of Conference??? Date of Conference???

5. Aikins-Wilson, S. 2019. Maternal and direct genetic parameters for tail length, tail lesions and breeding goal traits in pigs. Vortragstagung der DGfZ und GfT aus der Arbeit der Forschungsstätten für Teirwissenschaften. 11th-12th September 2019. Universität Gießen

6. Hagan, B. A., Moro-Mendez, J. and Cue, R. I. 2019. Realized genetic selection differentials in Canadian Ayrshire dairy cattle herds. Abstracts of the 2019 American Dairy Science Association Annual Meeting, Cincinnati, Ohio, USA, June 23-36

7. Antwi, C. 2019. Global Ecosystem for nurturing Multi-•disciplinary Research Innovation. International Science Technology Education, Arts, Management and Social Sciences (STEAMS). 15-16 November, 2019 at CSIR-Institute for Scientific and Technology Innovation