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CONTENTS

EFFECT OF GENOTYPE, AGE OF LAYER AND THEIR INTERACTION ON EGG QUALITY CHARACTERISTICS OF EGG-LAYER CHICKENS

Jambui M.L. and Quartermain A.R.[1]

ABSTRACT

A study was carried at the Papua New Guinea University of Natural Resources and Environment to evaluate the effects of genotype and age of laying bird on egg quality traits of egg-layer chickens. A total of 180 eggs were collected from three genotypes at 56 and 68 weeks of age. The three genotypes were Australorp and F_1 and F_2 crosses derived from crossing an Australorp sire line with the Shaver Brown commercial dam line. Thirty eggs from each genotype and age group were evaluated for external and internal egg quality characteristics. The traits measured were egg weight (EW), egg shape index (ESI), shell weight (SW), shell percentage (SP), yolk weight (YW), yolk percentage (YP), albumen weight (AW), albumen percentage (AP), albumen height (AH) and Haugh unit (HU). The effects of genotype were found to be significant ($P<0.05$) for ESI, SW, SP, YW and YP. The highest value for ESI was for the F1 and shell quality was better for the crosses than for the Australorp. By contrast, the Australorp had the highest yolk percentage of 28.77 percent compared to 27.86 and 27.30 percent for the F1 and F2 respectively. Egg and yolk weights increased significantly ($P<0.05$) by three and four percent respectively with increased age. Albumen quality was not influenced by differences in genotype and age. However, a genotype by age interaction was observed for AW, AP and YP. The Australorp had high AW and AP initially but these declined with increasing age compared to the crosses. The F1 had the highest YP in the beginning but the Australorp had the highest YP by week 68. The results suggest that differences in genotype and age of bird, and their interaction, may affect egg quality traits of layer chickens. Customers who buy crossbred eggs of the same weight would obtain less yolk than those who buy Australorp eggs.

Key words: genotype, age, egg quality, egg-layer chickens

INTRODUCTION

Improving egg production in Papua New Guinea (PNG) through developing low cost feeds and improving available chicken-types through crossbreeding is an ongoing program of the National Agricultural Research Institute and other stakeholders. This is to help provide alternative feed and chicken types for farmers who are often faced with problems of commercial feed and chick replacements being either too expensive or not accessible, especially in the island provinces.

Work done by the current authors (Jambui and Quartermain 2012) on the productivity of Australorps and their crossbreds with commercial Shaver Brown layers have shown that the crosses are more efficient in growth and egg production than the Australorp. In terms of egg quality assessment, Australorps had higher yolk color values than the crosses although there were no differences in shell thickness among the genotypes. Egg weight was higher for the crosses. Kobila (2012) also found the crosses to be more efficient in converting feed into egg weight and number.

Monitoring egg quality characteristics of egg-layer chickens is important in terms of production economy. This is because the economic success of a laying flock depends on the num-

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ber of high quality eggs produced. Egg quality may be divided into external factors, including egg weight, specific gravity and egg shell quality, and internal factors, including yolk quality, albumen quality and egg air-cell determination. These characteristics are influenced by a number of genetic and non-genetic factors including breed, age of hens, length of storage and season.

Genotype and age are two important factors that influence egg quality. Brown hens lay heavier eggs than white ones. The eggs are larger and have less yolk, more albumen and a greater percentage of shell than those from white hens (Heil and Hartmann 1997; Silversides and Scott 2001). Furthermore, Levendecker et al. (2001) showed significantly higher yolk weight in white egg chickens (Lohmann LSL) in comparison with the brown Lohmann Tradition. Moreover, other comparisons have shown that the Rhode Island Red breed and other brown egg strains, including commercial layers, have better albumen quality than the leghorn breed or other white egg strains (Knox and Godfrey 1934; Nordskog and Cotterill 1953). On the other hand, Tůmová et al. (1993) found significantly higher yolk weight and percentage in Hisex Brown with brown eggs than in D-29 with white eggs. Another study by Marion et al. (1964) reported that when eggs were divided within strain into large and small weight classifications, the larger eggs had less percentage yolk and more percentage albumen than smaller eggs. Genetic groups with larger egg size have less yolk and more albumen compared to groups laying smaller eggs.

The main differences in eggshell quality are between the white and brown egg laying hens. For instance brown egg layers D 102 had a higher shell weight in comparison with lines of White Leghorn (Ledvinka et al. 2000). In contrast, Basmacioglu and Ergul (2005) did not report a significant effect of the genotype on shell percentage and thickness. Brown eggs had a thicker eggshell than the white ones in one report (Silversides and Scott 2001) but Knox and Godfrey (1934) and Nordskog and Cotterill (1953) found a thinner shell in brown eggs. Egg Shape Index in the white hens Shaver Starcross 288 was higher than in the brown Moravia SSL (Halaj and Grofík 1994).

For albumen height, genotype plays a major influence (Ashraf et al. 2003; Scott and Silversides 2000) and results from the latter author showed that height of the inner thick albumen of the eggs from ISA-White hens was greater than in eggs of the ISA-Brown hens. On the other hand, Levendecker et al. (2001) found significantly higher values for Haugh Units in white layers than in brown hens.

Many studies on the effect of genotype on egg quality have compared differences between brown and white eggs from layers. However, the differences between layers are not due to a direct relation with egg shell color but rather due to differences in the genetic origins of the hens. Furthermore, results from Zhang et al. (2005) indicated that eggshell color had little, if any, relationship to external or internal egg quality. Thus the color of the egg is not associated with the quality of the egg.

Age of hen is another factor that influences egg weight. Studies by Silversides and Scott (2001), Van den Brand et al. (2004), Zita et al. (2009), and Baumgartner et al. (2007) showed that egg size increased with increasing age of the hen. On the other hand, Zemková et al. (2007) demonstrated that the egg weight was not influenced significantly by age. The age of hens also increased yolk weight (Van den Brand et al. 2004; Zita et al. 2009; Rossi and Pompei 1995; Suk and Park 2001), albumen weight (Zita et al. 2009; Rossi and Pompei 1995; Suk and Park 2001) and yolk proportion (Zita et al. 2009; Rossi and Pompei 1995; Rizzi and Chiericato 2005) but decreased albumen percentage (Van den Brand et al. 2004; Zita et al. 2009), egg shell percentage (Silversides and Scott 2001; Zita et al. 2009) and shape index (Van den Brand et al. 2004).

Numerous studies have also shown that Haugh Unit and albumen height decreases with age (Silversides and Scott 200; Ashraf et al. 2003; Atkan 2011). That is to say that the albumen height (thick albumen) was run down by the increasing age, even though egg weight and total amount of albumen increase. Younger hens had higher values of Haugh unit than older hens.

Not much work has been done in PNG up to now on egg quality of the available egg-layer chickens. Hence this study was carried out to assess the effect of genotype and age on egg quality characteristics of the Australorp (A), and its crosses F_1 (A x Shaver) and F_2 (F_1 xF_1).

MATERIALS AND METHODS

The study was carried out in 2011 at the University of Natural Resources and Environment (Vudal campus) located at152°00E and 04°21S with an elevation of 55 m above sea level. The mean annual rainfall is 2200 mm and mean annual minimum and maximum temperatures are 23 ^{0}C and 32 ^{0}C.

Six groups of birds were used in this study of which there were three genotypes and two age groups. Each group of birds had 20-25 hens. The genotypes were Australorp, F1 and F2 crosses. The F1 cross is a cross between Australorp roosters and Shaver Brown hens while the F2 is the result of crossing F1 by F1. There were two age groups per genotype, one of 56 weeks old and the other of 68 weeks.

On average, six freshly laid eggs were randomly collected each day for the six groups, for a period of five days. The eggs were transferred soon after being collected at the University poultry farm to the science laboratory to break and analyze. A total of 30 eggs were analyzed for each of the three genotypes in the two age groups giving a grand total of 180 eggs analyzed. Egg colors ranged from tinted white for Australorp to those of the F1 and F2 crosses which laid eggs that were of different shades of brown to light brown and tinted white.

The dependent variables measured were egg weight (EW), egg shape index (ESI), shell weight (SW), shell percentage (SP), yolk weight (YW), yolk percentage (YP), albumen weight (AW), albumen percentage (AP), albumen height (AH) and Haugh Unit (HU).

The eggs were numbered and weighed on a sensitive scale to the nearest 0.1 g. The width and length of each egg were measured using a vernier caliper (Smiec 0-150 x 0.02 mm) to determine egg shape index. Each egg was broken and its contents poured onto a flat white plate in order to measure the albumen height. Albumen height was measured as the height of the chalazae at a point midway between the inner and outer circumference of the white using an AMES micrometer. The yolk was separated from the albumen and then weighed, while the albumen weight was detected by subtracting the weights of yolk and eggshell from egg weight. Shells were weighed on the sensitive scale to the nearest 0.1 g after each egg was broken.

Other egg quality parameters were estimated using the following formulae:

Egg shape index = [length (cm)/width cm)] x 100 (1)

Albumen percentage = [albumen weight (g)/egg weight (g)] x 100 (2)

Yolk percentage = [yolk weight (g)/ egg weight (g)] x 100 (3)

Shell percentage = [egg shell weight (g)/egg weight (g)] x 100 (4)

Haugh Unit = 100 log (H+7.57 - 1.7 W $^{0.37}$) (5)

Where:

H = height of albumen
W = egg weight (grams)

DATA AND SOFTWARE ANALYSIS

Statistical analysis of the data on egg quality was performed using Genstat Discovery Edition 3 software by two-way analysis of variance. The model included the main effects of genotype and age and their interaction. Significant differences between means were determined by Least Significant Difference (LSD) at a level of $\alpha = 0.05$.

RESULTS

Tables 1 and 2 and Figures 1, 2 and 3 show the results obtained from this experiment. Interactions are shown graphically only for traits for which they were significant.

DISCUSSION

There were significant genotypic differences in external egg quality traits for shell weight, shell percentage and egg shape index but not for egg weight. SW and SP were significantly higher for both crosses, F1 (7.68g, 11.3%) and F2 (7.73g, 11.8%) than for Australorp (7.21g, 11.3%).

Egg shape index was significantly higher for the F1 cross (75.22%) compared to the Australorp (71.87%) and F2 cross (70.74%). An index of 74 percent is considered optimal and a variation between 72-76 percent is satisfactory. It can be seen that the narrower or longer the egg the lower the index. Thus the egg shape index of the F1 is satisfactory whilst

Table 1: The effect of genotype and age on external egg quality traits

Genotype	EW (g)	ESI (%)	SW (g)	SP (%)
Australorp	63.77±0.53	71.87±0.50a	7.21±0.13a	11.3±0.17a
F1	65.20±0.64	75.22±1.05b	7.68±0.11b	11.81±0.16b
F2	63.31±0.77	70.74±0.44a	7.73±0.15b	12.21±0.17b
Age				
55 weeks	63.10±0.60a	72.58±0.68	7.46±0.11	11.84±0.13
68 weeks	65.08±0.45b	72.64±0.55	7.62±0.10	11.70±0.15
Source of variation				
Genotype	NS	*	*	*
Age	*	NS	NS	NS
Genotype x Age	NS	NS	NS	NS

*P≤0.05

eggs of the Australorp and F2 are sharper i.e. shape index ranged less than 72 percent. There was no difference in the external egg qualities studied as age of birds increased except for EW. Yannakopoulos et al. (1994) also did not find significant differences by age for egg shell characteristics. EW increased from 63.10g at 56 weeks to 65.08g at 68weeks. This is similar to findings by Silversides and Scott (2001), Van den Brand et al. (2004), Zita et al. (2009), Baumgartner et al. (2007) and Ketelaere et al. (2002) who noted increasing egg weight with increasing age.

The quality of albumen is given by AW, AP, AH and HU in Table 2. None of these variables were affected by genotype and age of hens. AW ranged from 38.26g – 39.37g, AP from 59.98 - 60.47 percent, AH from 7.77 - 8.14 mm and HU from 86.53 - 88.53 percent. The HU values fell within the preferred range of 72 - 100 mentioned by Izat et al. (1985).

However, significant interaction (p=0.05) was observed for AW and AP and the trend is shown in Figures 1 and 2. Although both AW and AP were initially higher for the Australorp at 56 weeks, the values declined so that by week 68 both crosses had higher values.

Yolk weight and percentage were significantly influenced by differences in genotype of hens. The Australorp and the F1 had higher YW of 18.3g and 18.15g than the F2 (17.26g). For YP, the Australorp had the highest YP (28.77%) compared to both crosses (27.86%

Table 2. The effect of genotype and age on internal egg quality traits

Genotype	YW (g)	YP (%)	AW (g)	AP(%)	AH (mm)	HU
Australorp	18.30±0.22a	28.77±0.30a	38.26±0.41	59.98±0.32	8.05±0.17	88.05±0.94
F1	18.15±0.24a	27.86±0.30b	39.37±0.49	60.33±0.33	8.14±0.16	88.53±0.85
F2	17.26±0.21b	27.33±0.26b	39.32±0.55	60.47±0.28	7.77±0.18	86.53±0.99
Age						
56 weeks	17.53±0.20a	27.80±0.26	38.11±0.44	60.36±0.26	7.93 ±0.14	87.62±0.79
68 weeKs	18.28±0.16b	28.14±0.22	39.19±0.35	60.16±0.26	8.04 ±0.13	87.79±0.73
Source of variation						
Genotype	*	*	NS	NS	NS	NS
Age	*	NS	NS	NS	NS	NS
Genotype x Age	NS	*	*	*	NS	NS

*P≤0.05

Figure 1. Genotype and age interaction on Albumen weight

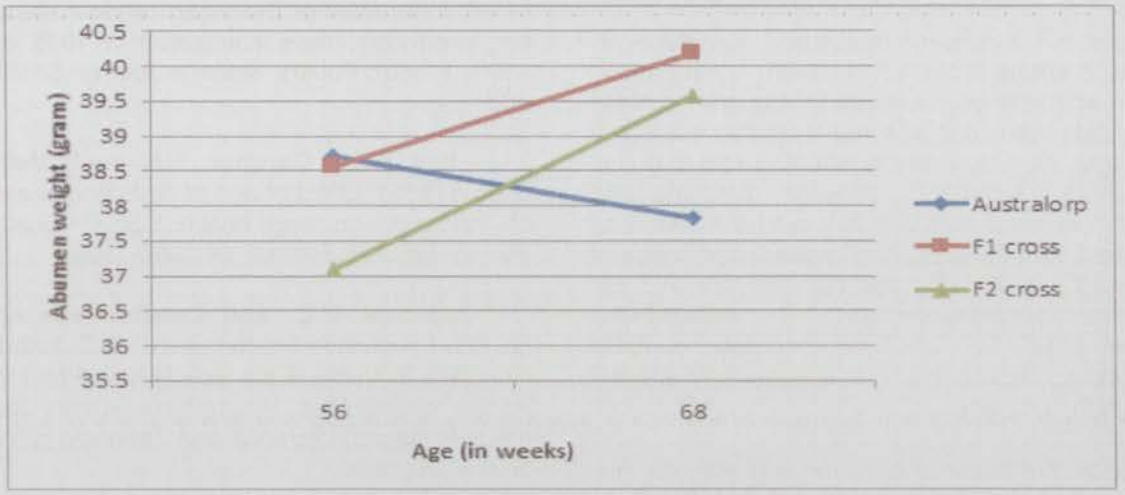

Figure 2. Genotype and age interaction on Albumen Percentage

and 27.33%). Significant interaction between genotype and age was found for YP as shown in Figure 3. The F1 cross had the highest YP of 28.10 percent at week 56 but by week 68 the Australorp had the highest YP of 29.5 percent. The trend seems to be that YP was increasing for the Australorp over time while it was decreasing for both crosses.

Generally, both crosses had less yolk, more albumen and greater shell percentage. This is similar to the results of Silversides and Scott (2001). The results from the crosses indicate that genetics contributed to the results showing similar trends to brown egg strains, as one of the parents is the Shaver Brown. Brown egg strains have better albumen quality than the leghorn or white strains. In the Australorp, YP increased with the age of hen as AW and AP declined. SW and SP were also low. These results for the Australorp are similar to findings from white egg strains and may relate to the genetic background of the Australorp developed from the Black Orpington. It is not the color of the egg that influences egg quality but rather the genetic background of the hen.

YW significantly increased with age from 17.53g at 56 weeks to 18.28g in week 68. One likely explanation is that, since egg weight influences the weight of its components, when EW increases with age so does yolk weight. Other studies that support the influence of increased age on increased yolk weight include Zita et al. (2009), Rossi and Pompei (1995) and Suk and Park (2001) .

CONCLUSIONS

From the results of this study, genotype affected shape index, shell weight, shell proportion and yolk characteristics. Albumen characteristics were not affected by either genotype or age. Age significantly affected egg and yolk weights. Interactions between genotype and age occurred for YP, AW and AP. As egg weight for the Australorp increases with age of hen, YP also increases but AW and AP decrease. On the other hand, YP is reduced with age while AW and AP increase for both crosses. The Australorp had lower SW and SP than the crosses.

The percentages of albumen and yolk are important to the egg breaking industry. Breakers who buy eggs of the crosses would obtain less yolk than those who purchase Australorp eggs.

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DEVELOPMENT OF MODIFIED COCOA DNA EXTRACTION METHOD

Noel Y Kuman, Paul W.J Taylor

ABSTRACT

This is the first attempt to study Papua New Guinea cocoa at the genetic level using molecular markers. To study cocoa at the molecular level, the first the step is to extract clean good quality Deoxyribonucleic Acid (DNA) to be used for DNA profiling. This paper described a modified method developed to extract good quality DNA, after attempts to use the conventional Cetyltrimethylammonium bromide (CTAB) based methods failed. The modified procedure developed was successful and used to extract high quality DNA and used to evaluate the genetic diversity of selected hybrid cocoa planting materials from Papua New Guinea.

Key Words: DNA fingerprinting, molecular markers, genetic diversity

INTRODUCTION

Protein (isozyme) analysis was first used to determine the polymorphism among cocoa genotypes (Atkinson *et al.*, 1986). The isozyme method was simple, but the limiting factor was the low level of polymorphism detected. In order to obtain a more accurate description of genetic diversity of genotype, molecular markers were used to analyse the DNA sequences. Variation at the DNA level using Restriction Fragment Length Polymorphism (RFLP) and Random Amplified Polymorphic DNA (RAPD) markers were used to study genetic diversity of cocoa. The use of these two markers were informative and comparable (N'Goran *et al.*, 1994), however, RAPD markers were chosen and used in the current study because the technique is fast, inexpensive, avoids the use of radioisotopes and requires minute amount of DNA for Polymerised Chain Reaction (PCR), compared to the RFLP technique. The technique is also less laborious and more suitable for use in developing countries.

MATERIAL AND METHODS

Twenty five accession of *Theobroma cacao*, which included 9 parental and 16 progeny genotypes were collected from one of the breeding trial conducted at Papua New Guinea Cocoa and Coconut Research Institute (Kuman, 2005). Healthy young fresh leaves were randomly sampled from each row of selected genotypes in the breeding trial. The sampled leaves from each genotype were packed separately inside plastic bags and labelled (which included the name of the genotype and date of harvest) and placed inside a 10 L polystyrene container half filled with ice. At the end of all collections, a full plastic bag of ice was gently laid on top of the samples and the polystyrene container was securely enclosed and transported to the University of Melbourne, Molecular Plant Genetic Germplasm laboratory for DNA isolation.

Sample treatment

The sample once brought into the laboratory were removed from the polystyrene container and stored immediately inside a -20 °C freezer. Prior to DNA extraction, one frozen leaf of each genotype was thawed, washed with distilled water and blot dried with paper towel. The midveins and petioles of the leaves were removed, and approximately 0.1 g of sample excised from each of the leaves and was used for DNA

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extraction. The remaining samples were stored in the freezer for later use.

DNA extraction

Many attempts were made to extract DNA from cocoa leaves by adopting different Cetyltrimethylammonium bromide (CTAB) methods, but none of them were successful. The first CTAB protocol adapted to extract cocoa DNA was based on the modified method of (Taylor *et al.*, 1995). The second CTAB protocol adopted was based on Crouzillat *et al.*, (1996) with the quality of reagents and chemicals specified reduced by 1/10 to extract approximately 0.1 g sample. The third CTAB method adopted was based on Laurent *et al.*, (1993) with exclusion of the last step of DNA purification that used Cesium chloride-Ethidium bromide. The forth CTAB method adopted was based on a protocol used to extracted DNA from mango (1999, S.Chungwongse, pers. comm.). The fifth CTAB method adopted was a modified of method 4. This involved doubling the strength of extraction buffers and inclusion of polyvinylpyrrolidone to purify the DNA extracted.

The last method adopted was the modified method described in this paper to successfully extract DNA after various prescribed methods from the literature used, failed to extract good quality DNA. This method involved using spin columns and propriety buffers from QIAGEN, Pty Ltd, Australia with modifications made to suit the requirement of the experiment. All the buffers, enzymes, spin column tubes and collection tubes used in this extraction were supplied as a kit including the standard DNA extraction protocol.

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The last method adopted was the modified method described in this paper to successfully extract DNA after various prescribed methods from the literature used, failed to extract good quality DNA. This method involved using spin columns and propriety buffers from QIAGEN, Pty Ltd, Australia with modifications made to suit the requirement of the experiment. All the buffers, enzymes, spin column tubes and collection tubes used in this extraction were supplied as a kit including the standard DNA extraction protocol.

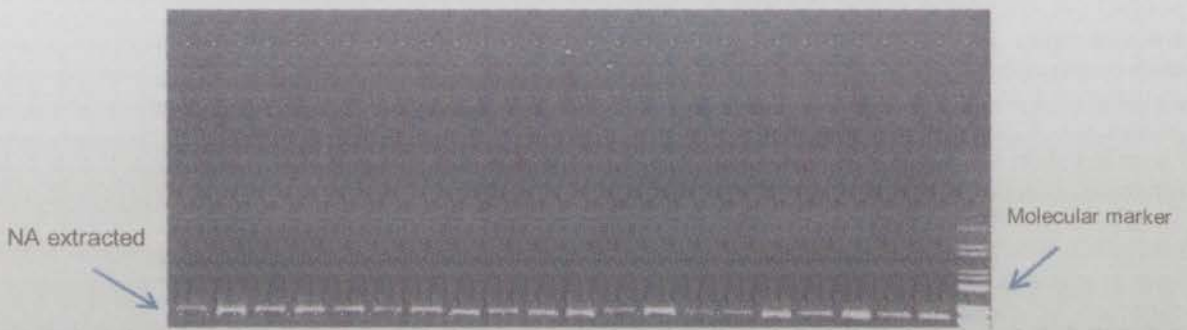
Modified DNA extraction method

The weight leaf (approximately 0.1 g) sample was ground in liquid nitrogen using a sterile molar and pestle and then transferred immediately into an Eppendorf tube. 100 µL of AP1 buffer and 4 µL Rnase A enzyme (100 mg /mL) were added to the ground sample and the mixer was vortexed vigorously. The sample was incubated for 10 min. at 65 °C and gently inverted and mixed three times during the incubation. After incubation, 130 µL of AP2 buffer was added to the lysate (mixture), mixed and incubated on ice for 5 min. The lysate was transferred into a QIA shredder spin column sitting on a 2 mL collection tube, and centrifuge at 1400 rmp for 2 min. The flow-through from the spin column was transferred into a new Eppendorf tube without disturbing the pellets of cell debris accumulated at the bottom of the tube. Buffer AP3 (250 µL) and 100 % ethanol (450 µl) were accurately measured and added to 450 µL clear lysate (flow- through) that was collected. The mixture (1150 µL) was thoroughly mixed by pipetting and gentle vortexing. The mixture was left at room temperature for 5 min. and then 650 µL of the mixture (AP3 buffer + ethanol + lysate), including any precipitate was loaded into the DNeasy mini spin placed inside a new 2 mL collection tube. The mixture was centrifuged at 800 rpm for 1 min. and the flow through discarded. This step was repeated for the remainder of the mixture. The DNeasy mini spin column was placed inside a new collection tube and 500 µL of AW buffer was added into the column and centrifuge at 800 rpm for 1 min. This step was repeated, and the mixture was centrifuge for 2 min. at 1400 rpm, to dry the column membrane. Ethanol (500 µL) was added into the column and centrifuged at 1400 rpm for 2 min. This step was repeated 5 times, to clean the DNA. The column was transferred to a 1.5 mL Eppendorf tube and 100 µL of preheated (65 °C) AE buffer was added directly into the column membrane and incubated for 5 min. at room temperature. The column was centrifuge for 1 min. at 800 rpm and the flow-through was collected. The elution step was repeated twice. The flow-through from each elution step was combined and precipitated with volume of chilled isopropanol (100 %). The DNA was precipitated and diluted with 30 µL of TE buffer (pH 8.0).

Extracted DNA was quantified using a spectrophotometer by measuring the absorbance at 260 nm; the approximate DNA purity was estimated by measuring the A260 nm/A280 nm ratio. Double stranded DNA that showed an OD of 1.00 is known to have a concentration of approximately 50 µg /mL and a pure preparation of ds DNA has an OD 260/OD 280 value between 1.80 and 2.00 (Maniatis *et al.*, 1982). Extracted DNA samples of the highest quality were used and each individual DNA stock concentration was diluted 10 ng /µL for PCR reaction. The RAPD-PCR amplification was performed after amplification of the DNA.

tion protocols were evaluated to extract cocoa DNA. None of the protocol was successful. All the (OD) reading for the stranded DNA extracted using the CTAB based methods were below pure OD range, which infers that extracted DNA could be contaminated (results not shown). When extracted DNA was separated by electrophoresis and visualized under UV, there was no DNA visible on the gel (results not shown). However the modified method using the QIAGEN Kit method produced good quality DNA.

Figure 1: Good quality DNA extracted shown on the gel after electrophoresis and visualized under UV light.



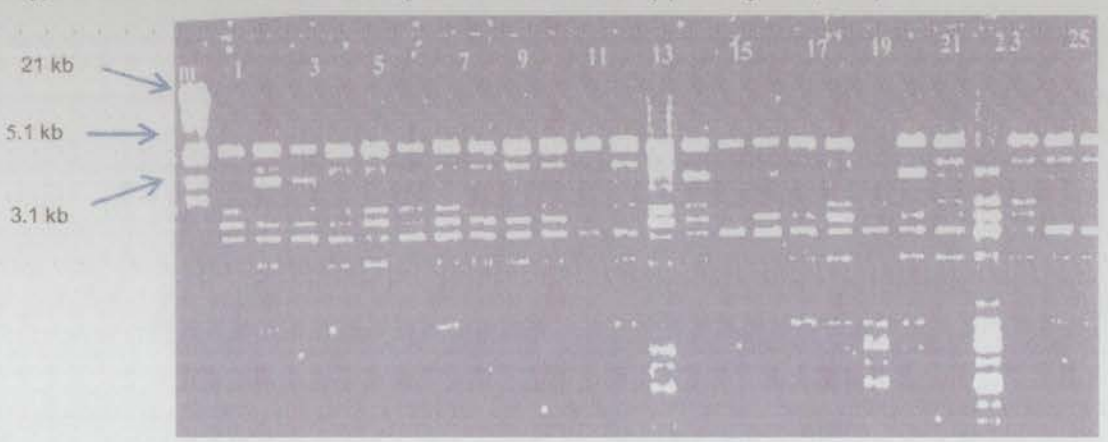
RESULT

DNA extraction

The biggest obstacle to any successful isolation of plant DNA is overcoming the problems of secondary products such as phenolic, quinones and protein contamination. In this experiment different CTAB-based DNA extrac-

The PCR amplification of genomic DNA with RAPD primers produce reproducible and distinct marker profile for genomic DNA extracted from each of the genotype. Each primer amplified between 4 to 15 markers, ranging from 0.56 to 21 kb (Figure, 2). A total of 122 useful markers were produced, of which, 79 % were polymorphic, an average of 5 loci per primer.

Figure 2: RAPD band after amplification of genomic DNA of cocoa genotype with OPW-04 from DNA of genotype KEE12. M = molecular marker (λ EcoRI/Hind III ladder) (Promega Inc, USA)



DISCUSSION AND CONCLUSION

The difficulty encountered in extracting cocoa DNA using CATB methods may be due to the inefficiency of the protocols to purify ubiquitous polysaccharides gum present in the cocoa leaves (Figueira *et al.*, 1994). Increasing the strength of detergents to releases DNA from cells, combined with Polvinylpyrrolidone (PVP) to remove phenolic compounds that formed strong H-bonded complexes, failed to purify the DNA. Mercaptobenzothiosazide and Metabisulfite were also used as antioxidants and phenol oxidase inhibitors, but this does not improved the quality of DNA.

However, good quality DNA was extracted using the modified method described using QIAGEN kit. The success of this method depended on the design of the QIAGEN kit to allow absorption of DNA onto a silica gel membrane and optimized removal of carbohydrate polyphenolic and other plant metabolites. The advantage of using the kit is that it has a unique microfilteration and homogenization unit that removes protein, polysaccharides and cell debris in a single step (QIAGEN protocol, 1977).

The modified DNA extraction protocol developed can be used to extract good quality DNA for PCR amplification and profiling especially, for materials that are difficult to extract using other CTAB based extraction protocols. The procedure can be used to extract DNA from any parts of plants for DNA profiling.

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PRODUCTIVITY OF AUSTRALORP CHICKENS IN PAPUA NEW GUINEA

Pikah Kohun, Monica Mazi, Ku Kobila, Michelle Jambui [1] and Alan Quartermain [2]

ABSTRACT

Australorp chickens as a pure breed and in crossbreeding systems are important in the development of appropriate egg production systems in Papua New Guinea. However, problems exist with the economic disposal of surplus male birds and there is little comparative data on egg production with birds on commercial diets. The work described in this paper was firstly an attempt to assess the utility of raising surplus male chicks on commercial broiler feeds and secondly to gather limited data on egg production by *Australorps* in comparison with commercial hybrid layer birds. The results show clearly that it would be uneconomic to try to rear *Australorp* males on broiler feeds but that egg production by *Australorps* can be economic in spite of a longer time to point of first lay and a later attainment of peak production compared to commercial hybrids. Also presented is a summary of work done in Papua New Guinea to assess the utility of crossbreeding *Australorps* with commercial hybrid layers to produce a more accessible and cheaper alternative to the commercial hybrids for smallholder farmers. Suggestions are made as to options for the future use of the *Australorp* breed in Papua New Guinea.

Key words: Australorps, egg production, crossbreeding, birds, hybrid layers,

INTRODUCTION

Rural households and smallholder farmers in Papua New Guinea (PNG) keep chickens or ducks for meat and eggs with higher proportions of owners in the coastal provinces compared with limited traditional poultry keeping in the highlands provinces. However, increasing numbers of farmers are entering into commercial small-scale production, especially of broiler chickens (Bourke and Harwood 2009). The PNG literature on village poultry has been reviewed by Quartermain (2000). Since 1964 there have been ongoing attempts to improve household poultry meat and egg production in rural areas by the distribution of birds of introduced breeds, mainly Australorp chickens and Muscovy ducks, and through some husbandry improvement suggestions (see Quartermain 2000). Australorps were chosen either to replace village chickens or to crossbreed with them to produce a more productive bird. However, such birds cannot be relied upon to sit on eggs and hatch them as required. There are also problems of sustainability of breeding flocks and provision of adequate feeding and management. In order to further assess the utility of the Australorp breed in emerging small-scale commercial production systems, research has been done to characterize the productivity of the breed under commercial conditions and to assess the possibilities in crossbreeding Australorps with commercial hybrid layer strains to produce a cheaper, perhaps hardier, but certainly a more accessible alternative to the available commercial birds. In such situations, use must be found for the large numbers of surplus males and there is little information available on the feed requirements, growth potential and time to slaughter or sale of live male Australorp chickens. Hence, a feeding trial with male Australorps was conducted as well as productivity assessment of the several alternative genotypes for egg production.

1. Growth of Male Australorps on Commercial Broiler Feeds

Management and data collection

This work was undertaken at the Labu lowland

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livestock research centre of the PNG National Agricultural Research Institute (NARI). Male Australorps and mixed-sex commercial hybrid broiler chickens (Ross strain) were compared with 18 birds of each type in a completely randomized trial with three replicates per strain and 6 birds per replicate. The birds were fed commercial starter for the first four weeks and finisher for the next four weeks but were allocated into six 2.5 m^2 pens at three weeks of age (the earliest Australorps could be sexed). Live weights and feed intake were measured weekly from four to eight weeks and compared by 't' test. Subsequently, the Australorp males, because they were only 25 percent of the size of the broilers at this time, were kept for six more weeks with continued weekly measurement of live weights and feed intakes.

RESULTS

Live Weights and Gains

The mean live weights of the two strains of chicken are shown in Figure 1. The male Australorps had significantly lower weights ($P<0.01$) compared to the mixed-sex broilers throughout the trial and by the end of the eight weeks their mean live weight was only 25 percent of the mean live weight of the broilers (730 v. 2934 g). Average daily gains from four to eight weeks were 16 and 72 g for the Australorps and broilers respectively. The mean weights of the Australorp males from eight to 14 weeks, also shown in Figure 1, indicate a continued slow growth (28g/day) and, although they had doubled in size by the end of 14 weeks, their mean 14-week weight (1589 g) was still only 54 percent the weight of the broilers at eight weeks .

Feed Intakes and Feed Conversion Ratios (FCR)

The estimated mean feed intake per bird per week (Figure 2) indicates that the male Australorps had significantly lower intakes ($P<0.01$) at 5, 6, 7 and 8 weeks compared to the mixed-sex broilers. The mean intake of the Australorps from 9-14 weeks of age was 917 g per bird per week but there was some feed spillage affecting this estimate.

The broilers were significantly more efficient ($P<0.01$) in converting feed to body weight gain compared to the Australorps, the overall mean FCR from four to eight weeks being 5.7

Figure 1. Mean live weights of male Australorps and mixed-sex broilers

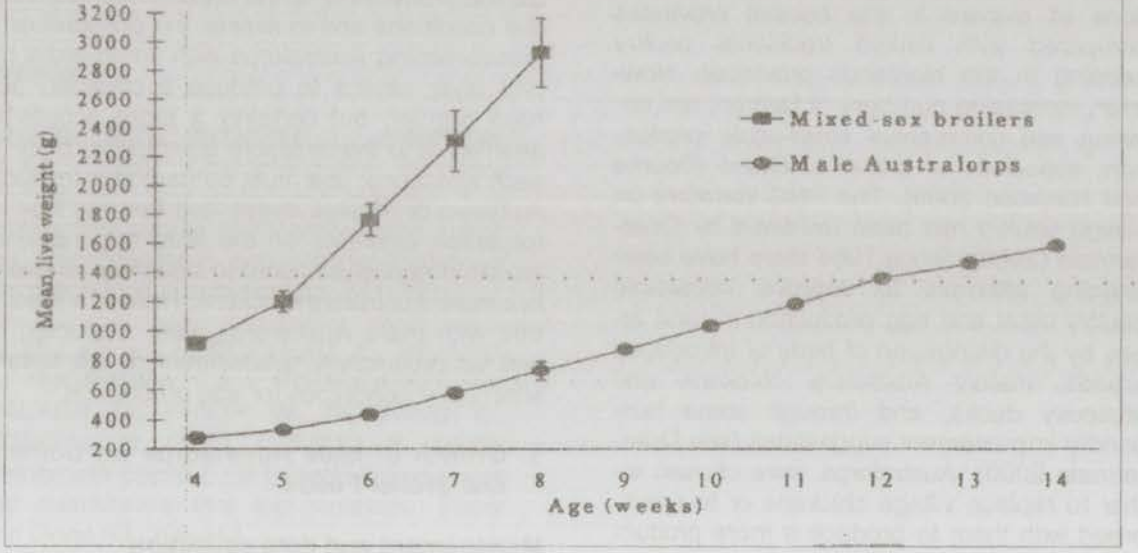
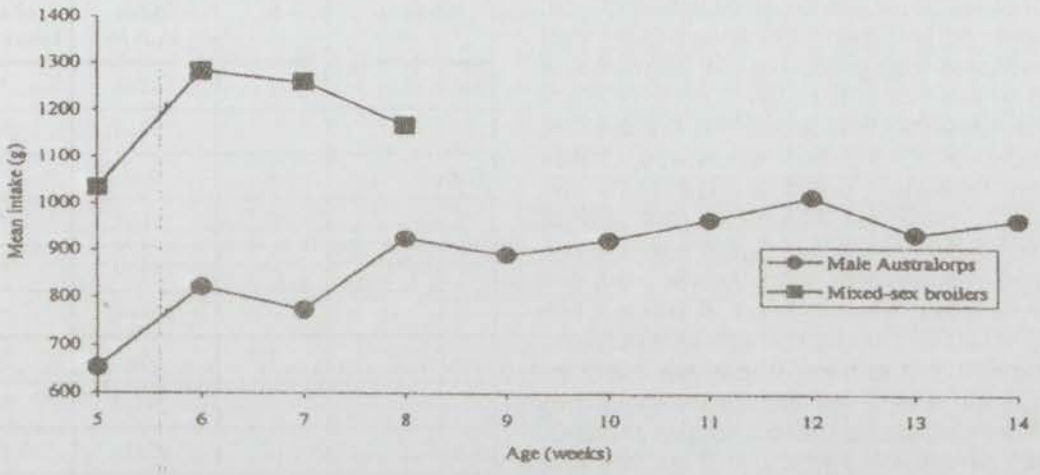


Figure 2. Mean feed intake of male Australorps and mixed-sex broilers



and 2.7 units of feed per unit of gain for the Australorps and broilers respectively. The mean FCR for the Australorps from 9-14 weeks of age was about six units of feed to one unit of gain.

CONCLUSION

As expected, the results of this trial showed that male Australorps grow much more slowly than commercial hybrid broilers. As a pure breed, the Australorps do not possess the same mix of genes required for efficient conversion of feed to meat and therefore cost more to produce than commercial broilers. Feeding Australorps on expensive commercial feed is obviously uneconomic. The Institute is conducting ongoing research to devise a more appropriate lower intensity feeding system, based on locally available resources, to enable farmers to make effective use of surplus male birds from Australorp layer production systems.

2. Egg Production of Australorps, Comercial Hybrids and their Crosses

MATERIALS AND METHODS

A preliminary trial at NARI Labu comparing the egg production potentials of Australorp and Shaver Brown hybrid layer chickens was started at the end of 2001 and ended in March 2003. One batch of 52 Shaver Brown pullets was purchased from Zenag while a batch of 50 Australorp chicks was hatched at the Labu center. Unfortunately, because of the small number of Australorp females available from the hatch, a total of only 20 birds, 10 of each of the two strains, were used in the trial. The birds were raised separately until point of lay then weighed and the mean live weight balanced between two replicates of each strain, 1387.2g and 1389.8g for Australorps and 1400.6g and 1397.0g for Shavers. The five hens in each replicate were kept in a 2.5 x 2.5 m room in a standard chicken house with iron roof and concrete floor with deep litter. Commercial layer feed and water were provided *ad libitum* and eggs were collected and recorded twice daily. The percent egg production per month over the 13 month period (30-day months) and the live weights of hens that survived to the end of the trial were analyzed using a completely randomized design to assess strain differences and determine whether Shaver production would be economically viable given the high cost of their replacement. Because the Shavers came into lay and therefore reached peak production earlier than the Australorps, the Australorp data were adjusted so that either point of lay or peak production were at the same time for both strains. Hence, two separate analyses of variance were done to compare egg production with either 13 or 11 months of data available for the two analyses of variance. Feed intake was estimated only during one week in the 10th month of lay.

RESULTS

The primary interest in this trial was to identify any important strain differences in egg produc-

tion over the laying period. A second interest was to determine if the Shavers could produce enough eggs to offset their replacement cost. The Shavers came into lay at 15 weeks of age, 4 weeks earlier than the Australorps, and reached peak egg production at 22 weeks of age, 5 weeks earlier than the Austalorps. During the 13-month trial period the numbers of egg produced by the Australorps and Shaver hens in replicates 1 and 2 were 1485 and 1146, and 1458 and 1743; giving a total of 2631 and 3201 for the two strains respectively. At K0.30 per egg, the gross income from this would be K789.30 and K960.30 for the two strains. The five Australorp hens in replicate 1 and the five Shaver hens in replicate 2 all survived to the end of the trial so for these two groups egg production per hen during the 390-day trial period was 297 and 349 (or 274 and 322 eggs in 360 days). Two Australorp hens died in replicate 2 and three Shaver hens died in replicate 1, giving a mortality rate of 20 and 30 percent for the two strains. The deaths were unfortunate, as they further reduced the already small number of birds and perhaps therefore affected the results of the trial.

Table 1. Analysis of variance of percent monthly egg production

Source	df	Mean square	Probability Level
Strain (S)	1	55746	**
		(31465)	(**)
Reps ®	1	6241	**
		(7160	(**)
Month (M)	12	25600	**
	(10)	(20144)	(**)
S x R	1	166	Ns
		(44)	Ns
S x M	12	5958	**
	(10)	(1627)	(**)
S x R x M	12	1028	**
	(10)	(1140)	(**)
R^2 (%)		50(45)	(**)

Analysis assuming the same time at point of lay

This first analysis of variance of percent egg production per month (Table 1, figures not in parenthesis), showed that strain, month, replicate and all interactions except strain x replication had significant effects (P<0.01). However, the means are not presented nor discussed as such because the small effects, although significant, cannot be regarded as reliable. Strain was the most important effect followed by month, but across all 13 months the Shavers produced 11.5 percent more eggs compared to the Australorps (85.0 +/- 0.64 v 73.5 +/- 0.64 percent). The strain x month interaction as illustrated in Figure 3 indicates that egg production was significantly higher (P<0.01) for the Shavers than the Australorps only in the 1st month (74 v 26 percent), 2nd month (98 v 75 percent), 8th month (91 v 78 percent), and 12th and 13th months of the trial (67 v 55 and 75 v 44 percent). In eight out of the 13 months of the trial, egg production did not differ significantly between the two strains, although it was always higher for the Shavers. On a weekly basis the data show some instances in which the Australorps had the same or higher production level than the Shavers, and a few of the cases where the Australorp production was higher and the differences were significant.

Analysis assuming the same time at peak production

This analysis of variance of percent egg production per month (Table 1, figures in parenthesis), gave similar results to the first analysis. Strain means, although dependent on month, again showed a higher production from Shavers than from Australorps by nine percent during the 11-month period (87 +/- 0.64 v 78 +/ - 0.64 percent). Replicate means and interaction effects are not presented nor discussed for the same reasons given earlier. The strain x month interaction for the 11 months of trial (Figure 4) shows many more months in which significant differences appear between the strains compared to the first analysis. The significant differences occurred in the 3rd, 5th, 6th, 7th, 8th, 10th, and 11th months; only in 4 of the months were the two strains similar in egg production. Thus, the comparison assuming the same time at peak egg production actually increased rather than reduced strain differences as might have been anticipated.

Costs and Returns

Live weights of the surviving hens from the two replicates were combined for each strain and the mean weights were 2098.5 +/- 96.50 and 1893.3 +/- 103.16 g for the 8 Australorps and 7

Figure 3. Mean monthly egg production (%) assuming the same time at point of lay for both strains

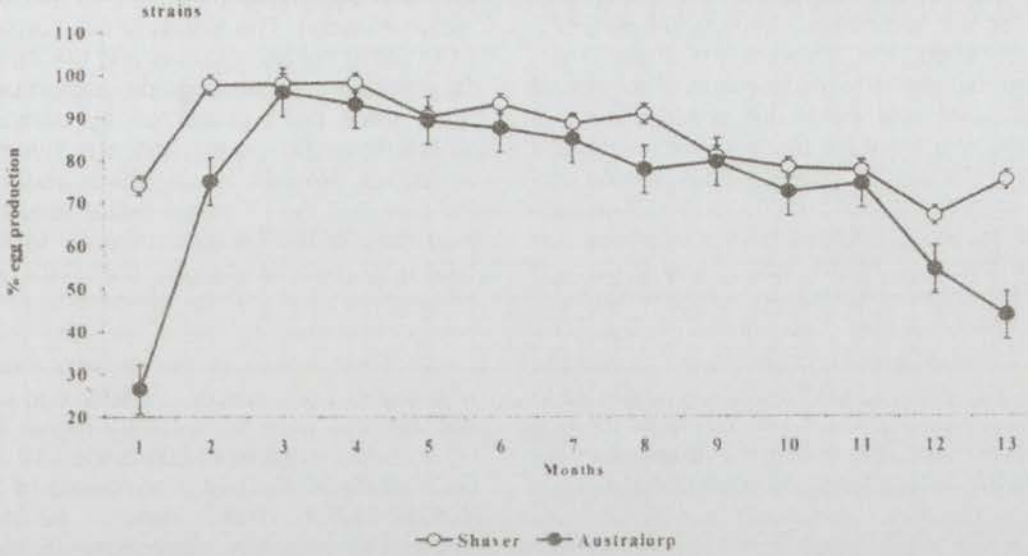
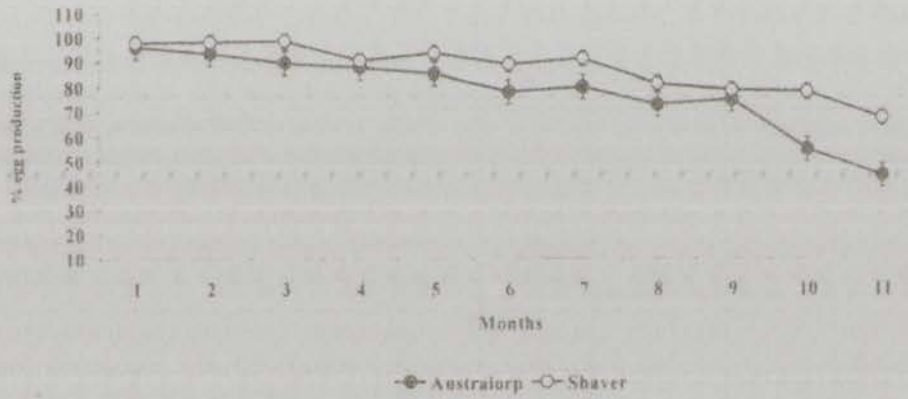


Figure 4. Mean monthly egg production (%) assuming the same time at peak production for both strains



Shavers, the difference being non-significant. The hens were valued at the time at K10.00 each for the purposes of the financial analysis.

Daily feed consumption per hen estimated during one week in the 10th month after start of laying averaged 105 +/- 5.0 g. Over the 13-months (all 30-day months) of the trial total feed consumed per hen would be around 41kg costing K52.00 based feed prices at that time.

Estimates of net income per bird for the two strains (Table 2) suggest a K12.57 advantage in favour of the Shavers, due mainly to their superior egg production potential. The estimates do not include capital infrastructure, management, water, electricity or other costs that might have been incurred.

DISCUSSION AND CONCLUSIONS

The Shaver hens had a higher mean egg production per month throughout the trial period and after reaching peak production maintained an average of over 90 percent lay for the next six months, whilst the Australorps maintained an average of over 90 percent for only four months after peak production. Production up to the 11th month of the trial averaged 87 and 83 percent for the Shavers and Australorps but, as expected, declined after

that and averaged 71 and 50 percent in the last two months of the trial, the decline being more rapid for the Australorps. It might still be profitable to keep the Shavers for these extra months but not the Australorps. The results suggest that Australorps can produce eggs at an economic level for up to about 11 months from start of laying, whereas Shavers can produce eggs for a few months longer. The estimated net income from Shavers at prices current at the time of the trial (Table 2) is high enough to allow a farmer to purchase replacement Shaver pullets and still have surplus income for other uses. It is concluded from these preliminary results that it would be profitable to keep Australorp and Shaver chickens for egg production but care should be taken with regard to the cost of feed and price of eggs.

Table 2. Estimates of net income per bird

Item	Australorp	Shaver
Costs of one day-old chick (Kina)	1.20	4.23
Amount of feed consumed to point of lay (kg)	7.4	7.4
Cost of feed consumed to point of lay (K)	9.35	9.35
Amount of feed consumed during trial (kg)	41	41
Cost of feed consumed during trial (K)	52.00	52.00
Total Cost (K)	**62.55**	**65.58**
Revenue		
Number of eggs laid	297	349
Income from egg sales (K0.30 per egg)	89.10	104.70
Income from one culled hen (K)	10.00	10.00
Total Income (K)	**99.10**	**114.70**
Net Income (Total Income—Total Cost) (K)	**36.55**	**49.12**

An alternative approach is to explore the utility of crossbreeding between Australorps and commercial egg production lines such as the Shavers. An experiment was conducted at the PNG University of Natural Resources and Environment with the objective of producing a crossbred egg-laying chicken for smallholder village poultry production in PNG. The exotic chicken breed used was the Shaver Brown (SB) as the dam line and the introduced pure-bred Australorp (A) as the sire line. Both F_1 crosses (AxSB) and F_2 crosses (ASBxASB) were produced. The results of two consecutive trials using the two crosses and the Australorp to assess growth and egg production performance have been presented by Jambui and Quartermain (in press) and are summarized as follows. Results of the growth performance indicate that the F1 has a better feed conversion ratio of 6.07-6.20 compared to the F2, 6.08-6.80, and Australorp, 6.22-6.60. Age at first egg was reduced for the crosses (115-120 days) compared to the Australorp (126-137 days). Feed intake of the crosses increased with higher body weight. Weekly egg number and weights were consistently higher for the F1 cross (5.66±0.095-5.94±0.19 and 54.37±0.49-56.00±0.57g) compared to the F2 (5.39±0.11-5.81±0.09 and 52.94±0.53-53.75±0.5) and the Australorp (5.25±0.09-5.21±0.09 and 52.84±0.59-55.08±0.62g). Yolk color scores were higher for the Australorp than the crosses; however, shell thickness was not affected by crossbreeding. From these results, the F_1 cross is shown to be the ideal genotype for smallholder egg-producing farmers.

The next logical step is to consider utilizing lower cost feeds for these strains of chicken with the aim of developing least-cost feeding systems for egg and meat production in the rural areas (Quartermain and Biat, in press). NARI research is addressing this and other related issues as means to satisfy the national government goals of food security and improved nutrition, self-sufficiency and income generation. Success would provide opportunities for rural people, especially women and children, to venture into egg and meat production to develop the rural economy and improve the livelihoods of rural households. Land availability is not a limiting factor for village chicken production and hence disadvantaged groups in the community can be the direct beneficiaries of such enterprises. Poultry production has been shown in many parts of SE Asia including Bangladesh, Myanmar and Indonesia, and elsewhere, to address gender issues in agriculture, with activities designed and financed to promote the formation of women's groups and associations for poultry enterprises. In Bangladesh, for example, chicken production has improved the status of landless women through improved access to food and income, as well as increased social status in the rural community (Saleque and Mustafa 1996).

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REVIEW OF AGRO-CHEMICALS USE IN THE AGRICULTURE AND LIVESTOCK SECTOR OF PAPUA NEW GUINEA

Noel Y. Kuman

ABSTRACT

Agriculture chemicals are widely available and used in the Agriculture and Livestock sector especially, by large coffee, oil palm and sugar plantations. Limited quantities of chemicals were used in the Cocoa, Coconut and Livestock industry. Smallholder farmers used very little to no chemicals; majority of the smallholder farmers produce organic produce. Fertilizer was the major chemical imported and used by the agriculture sector, followed by pesticides (herbicides, insecticide and fungicide). About 98 % of chemicals sold by chemical distributors were herbicides (glyphosate and paraquat), which are high in demand, with limited quantities of insecticides, fungicides and pesticides. Chemical distributors in the country distributed similar range of chemicals and the quantity based on local demand. The amount of agriculture chemicals imported increased by 9 % on average annually, correlated to the level of agriculture activities, though influenced by commodity price. Annual importation of fertilizer, fungicide, and insecticide increased on average by (9 %), (3 %), and (13 %) respectively. The common chemicals used in small quantities among the smallholder farmers were pesticides to manage pest and disease in fruits and vegetable production.

Key Words: Agriculture chemicals, pesticides, fungicide, insecticide. fertilizer

INTRODUCTION

Papua New Guinea (PNG) has a dual economy, comprising a formal corporate-based economy and a large informal economy, where subsistence farming accounts for the bulk of economic activities. The informal economy involved growing vegetables, tree crops and raisings livestock. Around 85 per cent of the population continues to rely on a combination of subsistence, and cash crop activities in the agriculture sector. Agriculture provides income and employment and a livelihood for over 85 per cent of the population, and absorbs about 40 per cent of formal private sector employment (DAL, 1995). It also contributes around one-quarter of GDP and over one-third of export income (World Bank, 1997). The smallholders predominantly dominate the food and livestock sector; growing staple root crops, fruits and vegetables either for consumption or for sale at small scale. They also farm cash crops mainly for export. The types of crops grown and animals raised are highly adaptive to the local environment.

Food crops account for more than 50 per cent of the total agriculture production, and only 25 percent of the produce are marketed. The marketing of the food crops is limited by availability and accessibility of markets and deteriorating or none existence of appropriate infrastructure. The smallholders are the driving force of subsistence production in PNG, and they accounted for about 85, 000 households (NDAL, 2001). The small holders traditionally produce 75 % coffee, 80% of coconut, 70 % of cocoa and 25 % of oil palm. Nearly all the cardamom and chilies and pyrethrum are produce by smallholder.

The major export cash crops; coffee, cocoa and copra are grown by all types of producers

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throughout the country depending on the soil and climate. Oil Palm, Tea, Rubber and Pyrethrum are other important export crops. Tea is grown almost entirely in the highlands on the estates. Rubber is grown in large holdings in the Southern coastal region, though smallholders grow them in limited quantities. Pyrethrum is grown in smallholdings and only in certain areas of the highlands. There is considerable scope of increases in production of both export crops and crops for local consumption. Imports of fresh fruits and vegetables could be considerably substituted by domestic production with appropriate government policies and support (NDAL, 2001).

Agriculture activities in the country have been on decline in the recent past; there have been little new developments or rehabilitations taking place in the agriculture sector, except for the oil palm industry. New developments have been reported in the Ramu valley in the Morobe and Madang province and East and West Sepik province. The export volume of most cash crops remains stagnant, decline or marginally increases in the recent past, with the exception of oil palm: the oil palm industry has been enjoying reasonably good and steady price over the years.

The quantities of chemicals imported into the country could be related to stagnant growth in agriculture sector and low commodity price. Many of the large coffee, cocoa and coconut plantations around the country have been abandoned, while other plantations had to change their management practices to replace or reduce use of chemicals to remain productive. The amount of chemicals used in the agriculture sector decreases over the years, except for the oil palm and coffee industry; large quantities of chemicals were used in this industry. Limited to no chemicals were used in other agriculture industry including, cocoa, coconut and rubber. Limited quantities of chemical were used in fresh produce industry, especially by few organizations or farms that produce large quantities of fruits and vegetables for local consumption and marketing. Limited to no chemical were used by the smallholder farmers.

Chemicals are required in some agriculture industries, especially by medium size farms as demanded by their operation, but they cannot afford these chemicals: instead the farmers relied heavily on inputs from family members and occasionally hired minimum labour to maintain the farming operation to remain productive.

The Internal Revenue Commission (IRC) is responsible for regulating the importation and export of chemicals in the country. IRC is empowered under the Customs and Exercise Act 1989 including, allied legislations. Though, the custom Acts does not have specific provisions in dealing with chemicals; chemicals are generally falls under the category of goods as defined in Section 1 of the Customs Act. Goods in this case, refer to all kinds of moveable personal property including chemicals. As such, the same treatment is applied to chemicals like any other goods under the Act. Unless, chemicals are categorized and come under the definition of prohibited or restricted imports; then the Customs (Prohibited Imports) regulation applies.

The Department of Environment & Conservation (DEC) is responsible for monitoring and regulating the import, use and management of chemicals in the country. The DEC is empowered under the Environmental Contaminants Act 2000 and (Pesticide) Regulation 1998, to undertake these tasks. Under the regulation, DEC is responsible for awarding import permits, transfer of permits, issuing of pesticide guidelines (for sales, importation, manufacture, distribution, promotion, advertisement and use), keep records of pesticide imports, provide packaging guidelines, scrutinize advertising, and impose fines for offences of non -compliance..

This report is based on a comprehensive survey conducted in 2003-2005 by the Department of Environment and Conservation under a project funded by United Nation Environment Protection (UNEP) and Global Environment Facility (GEF). In the nationwide survey, 48 major agriculture establishments were visited in the Momase (Morobe, Madang, East and West Sepik) Highlands (Eastern Highlands, Simbu & Western Highlands), New Guinea Island (West New Britain, East New Britain & New Ireland) and Southern (NCD, Milnebay & Popondetta). The survey covered major and minor chemical dealers (100 %), agriculture or related organization (90 %) including sampled 200 small smallholder farmers across the country. In total, around 90 % of the major agricultural establishments in each of the provinces of the 4 regions of the country were visited.

OBJECTIVE

The objective of the survey was to determine the status of Persistent Organic Pollutants

(POPs) or POPs-like chemicals including other agriculture chemicals in the Agriculture and Livestock sector of Papua New Guinea.

MATERIALS & METHODS

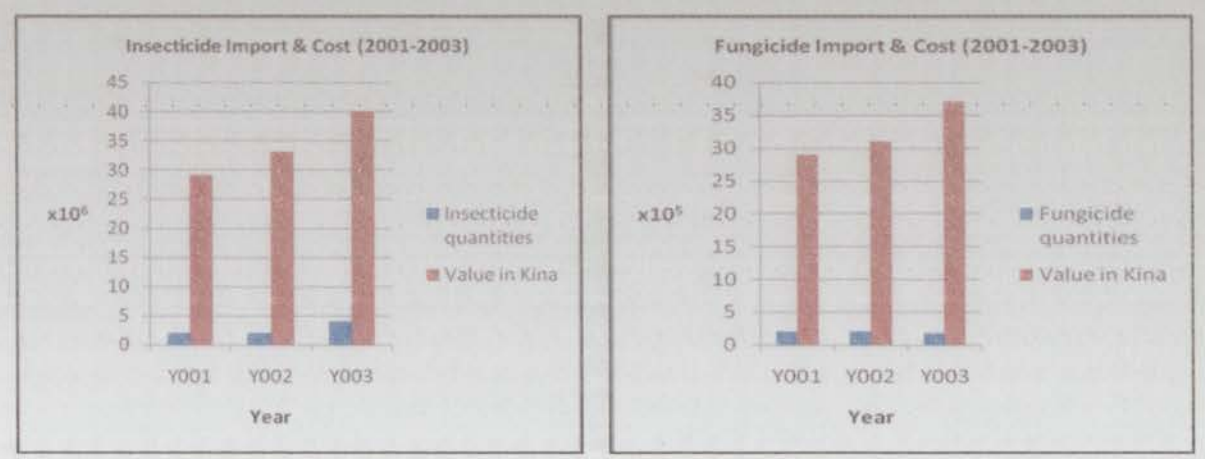
A standard survey form was developed (Kuman, 2005) and used for interviews in the survey to collect relevant data. Interviews were conducted using multi-method approaches (triangulation) (Denzin, 1989) to achieve broader and often better results. The research design was based on a combination of methodologies involving semi-structured interviews, questionnaire surveys, and review of relevant reports and published literature. The survey relied on in-depth qualitative interviews with the relevant stakeholders in the Agriculture and Livestock sector. The multi-method approach enables a comprehensive understanding of the real situation within the agriculture industry. The approach also provides a means of cross-checking the validity of the information and provides an accurate picture of the real situation.

RESULTS

The chemical market in the country is small but lucrative and chemical distributors across the country sell similar range of chemicals (Kuman, 2004) based on local demand. Most chemicals in large quantities were imported from Australia, New Zealand, Malaysia, Singapore and China while others in small quantities were also imported from other countries (Kuman, 2004). Most of the small chemical distributors got their chemical supplies from major dealers: the quantity of chemicals imported into the country is shown in Figure 1& 2. Given that not many agriculture activities took place in the recent years; there may not be significant change in the quantity of chemicals imported into the country, compared to average figures of 2001-2003 (Figure 1& 2). Generally, chemical importation remains constant over the years due to low commodity prices low number of new agriculture developments taking place in the country. In addition, large plantations have abandoned their operations or change their management practices to remain in business.

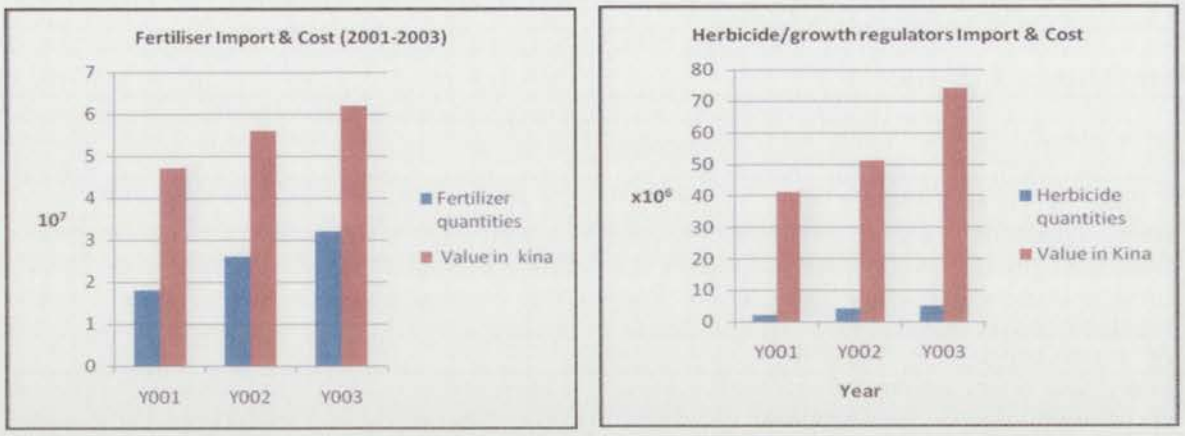
Figure 1& 2 shows the different types and quantities of agriculture chemicals imported into the country from 2001-2003. On average, 25.3 million tonnes of fertilizers worth 54.9 million kina, 0.3 tonnes of insecticides worth 3.4 million kina, 19 thousand kilograms of fungicides worth 325 thousand kina, 0.3 tonnes of herbicides and growth regulators worth 5.5 million kina. The highest amount of fertilizers (32 million tonnes worth 61million kina) were imported in 2003, with the lowest amount (18.1 million tonnes worth 47 million kina) were imported in 2001. The highest amount of insecticides (0.4 million tonnes worth 4 million kina) were imported in 2003, while the lowest amounts (0.2 million tonnes worth 3 million kina) were imported in 2001. As for fungicides, the highest amounts (19 thousand kilogram worth 300 thousands kina) were imported in 2003. The lowest amounts (18 thousand kilogram worth 360 thousand kina) were imported in 2001. The highest amount of herbicide growth regulators (0.5 million tonnes, worth 7.4 million kina) were imported in 2003, while the lowest amounts (0.2 million tonnes worth 4.1 million) were imported in 2001.

Figure 1: Agriculture chemical imports and cost (Insecticide) (a), Fungicide (b)



Source: IRC, 2004.

Figure 2: Agriculture chemical imports and cost (Fertilizer) (a), Herbicide (b)



Source: IRC, 2004

According to figure 3, the average pesticide used in large quantities was Glyphosate, (59 %, 9,300 L), followed by 2, 4-D amine (26 %, 4,167 l) and Paraquat (gramoxide) (11 %, 313 l) with other small quantities of chemicals (≥ 2 %). As for fertilizer, on average, Muriate of Potash was used in large quantities (52 %, 2,217 t), followed by Ammonia nitrate (36 %, 1,540 t) and Sulphate of ammonia (7 %, 283 t) with other forms of fertilizer (≥ 2 %).

and coconut plantations, combined rice, peanut and corn farms and piggery operations also used large amount of chemicals. Other organizations including, service providers or training institutions used limited to no chemicals in their operations. The smallholder farmers grow most of their crops organically. The chemical distributors do not supply all the chemicals range required especially, by large agriculture companies that use a lot of chemi-

Figure 3. An example of quantities of fertilizers (a) and chemicals (b) used in the Oil palm estates

Source: Handbook of Social & Environment, Pacific Rim Palm Oil, 2003

In Table 1, it shows the general distribution of chemical usage in the Agriculture and Livestock sector: this is indicated by the amount of funds spend annually to purchase chemicals. The major chemical users are the oil palm industry, followed by coffee, sugar and poultry; chemical are used in large plantations and livestock processing plant. Few large cocoa

cals; in most cases, these companies ordered their chemicals supplies directly from overseas. Occasionally, local chemical suppliers are contracted to order large quantities of chemicals required by large agriculture companies.

DISCUSSION

Table 1: Annual average chemical expenditure by different major agriculture or related organizations in the country

Industry	Pesticide (K)	Fertilizer (K)
Large piggery (produce 200 tonnes carcass/month and 200 tonnes corn/month	100,000.00	500,000.00
Medium size piggery (slaughter 1,000 pigs/month)	20,000.00	-
Large poultry processing plant (produce 840 tonnes chicken/ month	320,000.00	-
Large cocoa and coconut plantations (produce between 500-600 tonnes cocoa & coconut/year)	50-60,000.00	25,000.00
Large scale rice, corn, peanut & cattle farming combine	129,000.00	**
Large sugar plantation (>1,000 hectares)	**	**
Major pest control companies (>50 employees)	30,000.00	-
Large Oil Palm companies (>1,000 hectares)	1,000,000.00	1,500,000.00
Large chemical suppliers (>20 employees)	200,000.00 for both fertilizer and chemicals	
Small chemical suppliers (<10 employees)	100,000.00 for both fertilizer and chemicals	
Large coffee and tea plantation (>1,000 hectares)	500,000.00	3,000,000.00
Medium size coffee plantations (<40 hectares)	10,000.00	10,000.00
Small citrus farm (<20 hectares)	1500.00	-
Institution on training & farming (<20 hectares)	<2000.00	<3,000.00
Small scale farmers include piggery (<10) poultry (<40), cash crops & fresh produce farmers (<2.5 hectares)	Varies (between 100-300)	Varies (between 100-500)

The chemical importation has increased slightly over the years, largely influenced by the commodity prices. On average, a small increase was recorded in importation of fertilizer (9 %), fungicide (3 %), herbicide (13 %) and insecticide (12 %) over the years. Consecutive low commodity prices over the years has resulted in many large cocoa and coffee plantations been abandoned, as they become uneconomical to operate. An exception is the oil palm industry, which enjoyed a good steady price over the years, recording exceptional growth trend averaging 1.7 million tonnes per year: as the result, the industry continues to use large amount of chemicals as indicated by the amount of funds spend to purchase chemicals annually. Table 1, shows that, on average, 3 million kina was spent annually by a large oil palm company to purchase chemicals. However, there were four oil palm companies operating in the country at the time of survey therefore, the estimated amount of money used to purchase chemicals for the entire industry is estimated to be between 4-6 million kina annually to manage approximately 56,000 hectares of oil palm estate from a total of more than 100,000 hectares: the remaining hectares of oil palm is managed by the smallholder farmers. The total estimated cost is inclusive of chemical used by the smallholder farmers, given that most of the farmers get their chemicals supplies from major oil palm companies under the existing credit scheme arrangement. This figure may likely increase slightly as new large scale oil palm estates have been established in Ramu valley and further new developments are taking place in East and West Sepik provinces. Though, the ownership of the major oil palm company has changed recently, the amount of funds committed to purchase chemicals is likely to remain around the same or increase moderately. The reason being, many smallholder farmers are not using chemicals frequently under existing

credit scheme arrangement; companies are rationalizing chemical application method while others are integrating biological control methods into their operations. The oil palm crop heavily depended on chemicals to maintain or improve productivity and quality as compared to other crops. This means, the industry will continue to use large quantities of different types of chemicals to maintain and develop the industry.

Figure 2 and 3 indicates that there was an increase in fertilizer and pesticide importation from 2001-2003: this also corresponds to the cost, with more chemicals and fertilizer imported in 2003. According to chemical importation record (Figure 1), fertilizer was the major chemicals imported, followed by pesticides (herbicides, insecticide and fungicide).

Table 1, shows that large coffee and tea plantations in the highlands region and oil palm and sugar plantations in the coastal region used large quantities of fertilizer and pesticides. The type of chemicals used by the oil palm plantation is shown in Figure 3. The quantity of chemicals used by oil palm estates in different provinces varies: this could be due to high incidence of pest and disease in some locations as the result of high rainfall, soil type and management practices. Furthermore, research and development efforts are made in the oil palm industry with the aim to incorporate biological control methods as part of Integrated Pest Management (IPM) strategy to reduce chemical application, and hence minimize environmental pollution.

In the case of Livestock industry, large quality of pesticides and cleaning agents were used for general sanitation and pest/disease control management. Generally, companies have schedules to apply pesticides and fertilizers; large companies usually apply pesticides between 4-6 times per year, however all companies try to minimize chemical application as much as feasible to cut cost.

The smallholder farmers use very little to no chemicals; the amount of chemical used is shown by the amount of money spend annually (Table 1). The farmers apply minimum pesticides only in the event of pest or diseases outbreaks in their farms. Smallholder farmers used small quantity of chemicals such as herbicide (gramoxone) to manage weeds on ad hoc basis and applied integrated cultural practices to control disease. Beside, smallholder farmers including increasing numbers of large cocoa and coffee plantations have discontinued using chemicals for many years due to low commodity price and the high cost of chemicals and production. Instead, the companies depend on a healthy work force to maintain their plantation operations to remain in business. Study by Omuru *et al.*, 2001 shown that non-use of chemicals input by smallholder farmers in the cocoa and copra industry is attributed mostly to relatively high cost (85 %) of chemicals and lack of information (63%)- the same applies to other crops as indicated by the result of this study.

The chemicals distributors distributed a similar range of chemicals based on the demand across the country. The chemicals distributors do not supply all the chemicals required by the Agriculture and Livestock sector: many of the large agriculture companies imported their chemicals especially, fertilizers in large quantities directly from overseas. Glyphosate and Gramoxone are the fast selling chemical lines compared to other pesticides distributed in the major centers throughout the country (2004, S. Wood, pers. comm). Though, chemical market is small, it is a lucrative business; especially for large chemical distributors located in areas where there are major agriculture or related activities. However, this is not the same for medium to small size chemical distributors; they do not sell chemicals only but other products as well such as hardware, clothing etc. to remain profitable.

CONCLUSION

The quantity and different types of agriculture chemicals especially, the herbicides and fertilizer used in the Agriculture and Livestock sector in the country are likely to increase in future due to increasing agriculture activities as a result of anticipated shift from subsistence into semi-commercial or commercial farming. This is in line with anticipated governments support to the sector. In future, more chemicals are likely to be used as the result of (a), improved infrastructure across the country, especially in the rural areas (b), better government incentive package for the sector and (c) combine with increasing demand of agriculture commodity both locally and internationally. This means there is also a need for a stringent chemical use and management policies and regulatory system in the country; the current regulatory and monitory system is weak and there were reports of the system being abused. There is also a need to promote environmental friendly methods such as integrated

pest management to minimize use of chemicals to reduce environmental pollution.

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EFFECTS OF UREA-MOLASSES-MINERAL-BLOCKS (UMMB) ON THE GROWTH PERFORMANCE OF GOATS (*CAPRA HIRCUS*) MAINTAINED ON NATURAL PASTURES IN PAPUA NEW GUINEA

Lucy Lapauve and Gariba Danbaro

ABSTRACT

Use of urea molasses mineral blocks (UMMB), as feed supplements for goats to improve productivity, especially on farms which depend mostly on fibrous feeds of low nutritional quality in Papua New Guinea (PNG) is limited. This study was therefore conducted to investigate the growth of goats fed on UMMB in terms of their live weight gains (LWG). There were three treatments at each site: Treatment I goats were fed on natural pastures alone without UMMB. Treatment II goats were given an additional supplement of UMMB containing 5% urea and Treatment III goats were given an additional UMMB supplement containing 10% urea. Nine wether goats were randomly assigned to the treatments at each site. The goats grazed the normal pastures during the day and were offered the UMMB as licks only during the night (4pm to 8am next morning). LWG of the goats were measured over 16wks trial period The treatments had significant effect on LWG at both sites ($P<0.05$). LWG of goats on treatments I, II and III were 0.90±0.50kg, 0.47±0.50kg and 4.60±0.50kg respectively at NARI Labu station and -0.2±0.5kg, 2.1±0.5kg and 2.2±0.5kg respectively at Leron farm. LWG of goats in treatments I and II were statistically similar but significantly lower than that of goats in treatment III (LSD, $P<0.05$). However results of the on-farm trial showed that goats on treatments II and III had statistically similar LWG which were significantly higher than LWG of goats in treatment 1. The better performance of goats on UMMB especially on-farm where pastures were nutritionally poorer than those on-station suggest that UMMB technology could be used to increase growth and productivity of goats especially on commercial smallholder and subsistence farms in PNG.

Keywords: *Urea molasses mineral blocks (UMMB), goats, Papua New Guinea, growth performance.*

INTRODUCTION

Animal production is an important part of the agriculture sector of Papua New Guinea (PNG) which contributes to food security and livelihoods of people especially in the rural areas, where about 85% of the populace live. The main ruminant farm animals of PNG are cattle, goats and sheep in order of importance. According to Vincent and Low (2000), goat numbers in PNG were 17,000 (double that of sheep) as far back as 1992 with more than 90% are owned by smallholder farmers. Bourke and Harwood, (2009) further stated that meat goat numbers have increased steadily over the past 30 years despite little or no government encouragement and that there is a potential of milk production from goats.

One important problem of smallholder and subsistence goat production in PNG is poor nutrition of the animals which affects efficiency and productivity of the animals and profitability of the enterprise. Goat production especially on subsistence and smallholder farms in PNG depends mostly on natural pastures with little use of supplements and crop residues. However, natural pastures do not often provide

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sufficient nutrients to meet the nutritional requirements of these animals. During the rainy season these pastures are lush green with high moisture but low dry matter content and mature rapidly; but in the dry season these pastures tend to have high fibre content and are often deficient in nitrogen, energy and vitamins (Leng, 1983; Bheekhee, 2010). Thus the availability or quantity and balance of nutrients in goat feeds is often poor and this leads to poor growth and long term negative effects on health, fertility and productivity. To improve production in such systems, the efficiency of utilization of the available feed resources can be optimized by using supplements such as urea-molasses-mineral blocks (UMMB), that can provide the deficient nutrients and stimulate activity of rumen microflora.

UMMB are licking blocks, specifically for ruminants, which can be formulated to contain urea, molasses, vitamins, minerals and other nutrients. Feeding of the blocks can be a convenient and affordable method of providing a range of nutrients which may be deficient in the basal diet of forages but required by both the rumen microbes and the animal. The blocks are convenient for packaging, storage, and transport and easy to feed to ruminants (FAO, 2004). The ingredients can be chosen to provide a wide range of nutrients to cover all potential deficiencies in an area or region. For example, in the wet tropical regions where minerals are often deficient in cut and carry grass or crop residue feeding systems (FAO, 2004). UMMB licks can improve the utilization of low quality roughages by satisfying the requirement of the rumen microorganisms for nitrogen (present in the urea as a non-protein nitrogen, NPN) and energy (present in the molasses), creating a better environment for the fermentation of fibrous material and increasing production of microbial protein and volatile fatty acids (Makkar, 2002; Singh and Singh, 2003 Misra, *et al.*, 2006; Bheekhee, 2010; Khanum *et al.*, 2010).

As mentioned previously, most subsistence and smallholder goat farmers in PNG feed their animals on natural pastures and no supplements are usually provided. Even though supplements such as UMMB can be used to improve nutrition, most small scale livestock farmers in PNG are probably not aware of it and do not use this technology on their farms to achieve greater productivity. Furthermore the use of local ingredients to formulate UMMB in the PNG context will help to secure goat production enterprises sustainably in the long term.

The objective of this study was therefore to evaluate the growth performance of goats which were fed UMMB on the station and on-farm in terms of live weight gains in PNG. On station trials usually provide nearly ideal conditions where many extraneous factors which could possibly influence results of trials can be controlled so that the effects of treatments could be better observed. On the other hand, on-farm trials have the advantage that the farmer is closely involved in the design and execution of the experiment therefore, the farmer's views and conditions are accommodated in the trial. This makes it easier for the farmer to better understand the problem being tackled and the solution being proposed thereby facilitating adoption, if the results prove to be positive. However one important disadvantage of on-farm trials is that certain factors which could affect the results are often more difficult to control compared to an on-station trial. It is hoped that this study will contribute to understanding how UMMB technology can be used to the benefit of commercial smallholder and subsistence goat farmers in PNG.

MATERIALS AND METHOD

Site of experiments

Two trials were conducted, one on-station and the other on-farm using two types of UMMB at both sites. The on-station trial was conducted at the livestock research station of the National Agricultural Research Institute (NARI) at Labu, from April to July in 2013. Labu is located about 12 km from Lae city on the Wau-Bulolo road (Lat. 6° 40' 27" S, Long. 146°54' 33" E). The climate at Labu is typically warm and wet with an average temperature of 32°C. The main pasture species on the station were para grass (*Bachiaria mutica*) and koronivia grass (*Brachiaria humidicola*). Goats were usually allowed to graze the pastures from morning till afternoon after which they were returned to an open shed in the night. In addition to the pastures goats were also given cut forages of elephant grass (*Pennisetum purpureum*).

The on-farm trial was carried out at Leron farms from June to September in 2013. Leron farms is in the Markham valley (Lat. 6° 43'0.01", Long. 147°1'1.19"), approximately 70km from Lae city on the Highlands highway and the farm was under smallholder commer-

cial type of management. The climate at Leron is tropical humid with an average rainfall range of 162-426mm and average temperature of 28°C. The main pasture species on the farm were *Imperata cylindrica* and *Leucaena sp*. Goats usually graze the natural pastures and forages whenever the farmer allowed them out for grazing. No cut-and-carry forages were provided to goats.

Goats at both sites were fed on cultivated and natural pastures and there was no routine feeding of supplements.

Treatments and animals

There were two treatments and one control at each site. The first treatment (Treatment I) consisted of goats which were fed only the normal basal diet without UMMB. This basal diet consisted solely of natural pastures and forages which were grazed by goats at the trial site. The second treatment (Treatment II) consisted of goats which were fed a UMMB supplement containing 5% urea, in addition to the basal diet and the third treatment (Treatment III) consisted of goats which were fed UMMB supplement containing 10% urea. Each of the three treatments was replicated three times and each replicate consisted of one goat. Therefore nine goats were used at each site giving a total of 18 goats for both sites. All goats selected for this study were young wether male goats. The goats were nearly of the same age and were randomly allocated to the treatments. At the start of the trial, average age (wks) of goats on treatments I, II and III were 19.5 ± 0.5, 19.7 ± 0.5 and 19.6 ± 0.5 respectively at NARI Labu station and 16.3 ± 0.5, 17.0 ± 0.5 and 16.7 ± 0.5 respectively at Leron farm.

All goats were drenched with 5ml of Panacur 25 against internal parasites before the trial started. All goats at each site grazed on the pastures together during the day. However after about 4pm all goats were herded into the shed at the site and goats belonging to different treatments were kept in different pens overnight. Goats on treatments II and III were then provided with UMMB and they had free access to the UMMB lick overnight. The UMMB block was provided in a wooden container which al-

Table 1: Composition of experimental urea molasses mineral blocks (UMMB) for goats

Ingredient	Content (%) in Treatment II	Content (%) in Treatment III
Molasses	40	40
Quicklime	10	10
Salt (sodium chloride)	5	5
Soya bean meal (SBM)	10	10
Bone meal	5	5
Rice bran	25	20
Urea	5	10

Table 2: Proximate composition of UMMB

Nutrients	Ash %	Moisture %	DM %	CP %	CF %	Ca %	Fe mg/kg	Mg %	P %	Na %
Content in Treatment II	21.6	19.2	80.8	21.3	0.62	8.49	714	0.39	0.69	1.8
Content in Treatment III	21.6	20.3	79.7	35	3.23	4.97	472	0.33	0.59	2.39

Legend: DM = Dry Matter, CP = Crude Protein, CF = Crude Fat, Fe = Iron, Ca = Calcium Mg = Magnesium, P = Phosphorus, Na = Sodium

lowed free licking but prevented biting of the blocks by the animals. Water was freely available to all goats at all times during the trial.

UMMB composition and analysis

A standard UMMB lick block was prepared for feeding goats on treatments II and III at both trial sites. The proportions of ingredients which were used to prepare UMMB are shown in Table 1. UMMB used for treatments II and III differed only in their content of rice bran and urea.

Proximate analysis of UMMB was performed at the PNG University of Technology Analytical Services Laboratory (UASL) in Lae, Morobe Province according to the procedures of the Association of Official Analytical Chemists (AOAC, 1990). Results of the analyses are shown in Table 2. Treatment III UMMB had higher content of crude protein, crude fibre and sodium but lower amounts of calcium, iron, magnesium and potassium compared to treatment II UMMB.

Preparation of UMMB

To make the UMMB, all ingredients sufficient to make a 1kg UMMB were weighed using a scale balance. Next, urea was added to molasses in an iron pan and stirred with a wooden stick for several minutes to mix the two ingredients thoroughly. Then, in another container, quicklime was mixed with salt and similarly stirred thoroughly. The contents of the two containers were then mixed with each other and finally the rest of the ingredients (soya bean meal, bone meal and rice bran) were added one after the other to the mixture while stirring with a stick. The uniform semi-solid mixture produced was then poured into a rectangular wooden frame lined with a polythene sheet and pressed by hand for 20-30 seconds. The UMMB was left for 3 days to dry after which the wooden frame was carefully removed to leave a half-dried but intact UMMB on the polythene sheet. The UMMB was kept in a shed at room temperature for another 3 days to air-dry and also harden enough for handling, transporting and feeding to the goats.

Data collection and analysis

The trials at both sites were conducted for sixteen weeks after an adaptation period of 2 weeks. At Leron farm the farmer was given training on feeding of goats with UMMB, data recording and overall management of goats during the first two weeks adaptation period.

Figure 1. Weekly liveweight of experimental goats at NARI Labu

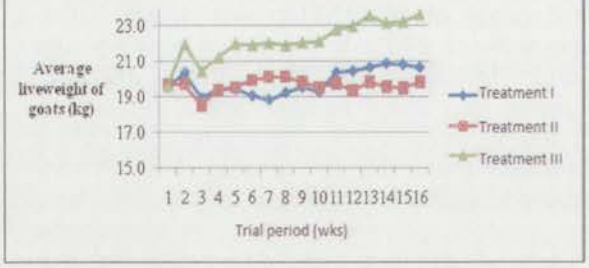

Figure 2. Weekly liveweight of experimental goats at Leron farm

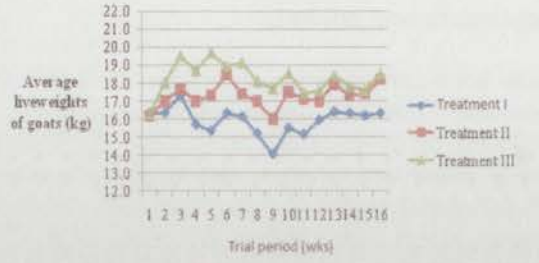

Table 3: Average weight gains (kg) of goats on different treatments.

Treatment	N	NARI Labu site	Leron farms site
Treatment I (control group)	3	0.90 ± 0.5^{a}	-0.2 ± 0.5^{a}
Treatment II (5% urea UMMB)	3	0.47 ± 0.5^{a}	2.1 ± 0.5^{b}
Treatment III (10% urea UMMB)	3	4.60 ± 0.5^{b}	2.2 ± 0.5^{b}
Note: Numbers with the same alphabet suffix within a column are not significantly different (P = 0.05			

The farmer's daily routines and activities continued as usual and UMMB was given as an additional supplement to goats on treatments II and III. A technical assistant was similarly trained to manage the experimental goats and collect data at NARI Labu. Furthermore the first author made weekly visits to both sites to monitor the trial, replenish stocks of UMMB, measure body weights and check on the general health and management of the animals. Weekly live weight of goats was measured at both sites. Weight gain of goats was calculated as the difference between live weight in the first and last weeks of the trial. Data on weight gains of the goats were subjected to single factor analysis of variance (ANOVA, Steele and Torrie, 1980). Where the results of ANOVA indicated significant difference among treatment means, then mean separation was carried out using the least significant difference test (LSD, P=0.05).

RESULTS AND DISCUSSION

Live weight changes of goats fed UMMB.

Trends in weekly live weight of the goats at NARI and Leron farm are shown in Figures 1 and 2 respectively and average live weight change of goats at both sites are shown in Table 2.The results shown in Figures 2 and 3 and Table 3 suggest that goats fed on UMMB supplement containing 10% urea gained significantly more weight than goats fed on natural pastures alone throughout the trial period at both sites. Results of the on-station trial at NARI Labu show that goats on treatment II (UMMB containing 5% urea) had statistically similar weight changes as goats on pastures alone (Treatment I). On the contrary, however, goats fed on UMMB supplement containing 5% urea gained significantly more weight than goats fed on natural pastures alone during the on-farm trial at Leron farm where the nutritional challenge to goats was more severe. Pastures on the farm were mostly *Imperata cylindrica* which is, nutritionally, a low quality grass with low digestibility and high lignification (Holmes *et al.*, 1980) compared with pasture species on-station. During the trial period pastures on the farm were mature and partially dry but goats on the farm were not given additional cut and carry forages as was done during the on-station trial at NARI. As mentioned earlier, the usual practice of most small scale goat farmers in PNG is that they do not offer additional forages to their animals apart from the pastures. It is therefore not surprising that goats on pastures alone (Treatment I) on the farm actually lost weight during the trial period (see Table 2) and that UMMB supplement containing 5% urea made a significant impact on weight gain of goats. Poor performance of goats which are fed fibrous feeds without supplementation is often attributed to low efficiency of utilization of the feeds due to low contents of nitrogen, energy, minerals, vitamins and other characteristics that restrict intake and digestibility such as high crude fiber and lignin content (Smith, 2002).

The relatively better weight gains of goats which were fed with UMMB containing 10% urea in this study, is in agreement with the findings of Saddul *et al* (1999), Makkar, (2002); Singh and Singh, (2003); Misra, *et al.*, (2006); and Khanum *et al.*, (2010) all of whom found that UMMB supplementation of ruminants improved weight gain as well as feed intake and body condition. Better performance of ruminants supplemented with UMMB, especially when quality of fodder is poor is often attributed to a more balanced supply of nutrients to the animals. UMMB provides other nutrients that are low in natural pastures and forages such as fermentable nitrogen, energy and minerals that are necessary for optimum microbial growth in the rumen. Under poor pasture conditions UMMB provides the much needed nitrogen in the form of NPN, fermentable carbohydrate in the form of molasses as well as certain minerals and an optimum pH in the rumen which allows cellulolytic bacteria in the rumen to flourish and increase rate of passage of digesta through the rumen. This may lead to goats eating more forages and increasing their live weights accordingly (Costello, 2005; Tiwari *et al*, 2008).

Farmer's perception

The participating farmer at Leron farm reported that goats consumed more forages when supplemented with UMMB and maintained good health. The farmer readily accepted the practice of using UMMB supplementation and is willing to continue in future, if these were available in the local market. The farmer further observed that the benefits of UMMB feeding were not visible immediately. It took at least two to three weeks and regular licking of the UMMB by the goats for the effects of UMMB to be observed visually. For effective utilization of UMMB, it is essential that UMMB must be placed in a location that is accessible to the animals so that they could easily lick the blocks as and when necessary. Under smallholder condition, however, this was not easy to achieve because of many reasons including goat shed design and management practices. In this study, goats were kept in separate pens in the shed in a limited area where they had access to the blocks.

CONCLUSION

The results of this study strongly suggests that UMMB containing 10% urea could make a significant impact on the live weight gains and therefore productivity, of goats on smallholder farms in PNG where pastures and forages are unimproved and usually of poor nutritional value. The UMMB could be fed to goats during dry seasons when good quality forages are mostly unavailable and during critical periods like just before the mating period, during late pregnancy and during the lactation period to increase fertility, milk production and kid survival.

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INDEX

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INDEX
1980 - 2012

CONTENTS

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LIST OF ARTICLES

1980 – 2013

1. **Rose, C.J., and Wood, A.W.** (1980). Some environmental factors affecting earthworm populations and sweet potato production in the Tari Basin, Papua New Guinea Highlands. 31(1-4): 1-13.

2. **Ghadhokar, P.A.** (1980). Comparison of stylo (*Stylosanthes guianensis* var *guianensis*) cultivars in the Markham Valley of Papua New Guinea. 31(1-4): 15-21.

3. **Rose, C.J.** (1980). Optimum replanting stage for two varieties of pitpit(*Setariapalmifolia*) in the highlands of Papua New Guinea. 31(1-4): 23-29.

4. **Shephered, A.** (1980). Replanting on copra plantations. 31(1-4): 31-35

5. **Smith, E.S.C.** (1980). *Zophiuma lobulata Ghauri* (Homoptera: Lophopidae) and its relation to the Finschafen coconut disorder in Papua New Guinea. 31(1-4): 37-45.

6. **Holmes, J.H.G.** (1980). Toxicity of *Leucaena leucocephala*. II: reduces fertility of heifers grazing *Leucaena leucocephala*. 31(1-4): 47-50.

7. **Holmes, J.H.G.; Lemerie, C. and Schottler, J.H.** (1980). *Imperata cylindrica* for cattle production in Papua New Guinea. 31(1-4): 51-62.

8. **Room, P.M.** (1980). Insect fauna of oil palm in the Northern Province of Papua New Guinea. 31(1-4). 63-67.

9. **Rose, C.J. and White, G.A.** (1980). Apparent digestibilities of dry matter, organic matter, crude protein, energy and acid detergent fibre of chopped, raw sweet potato (*Ipomoea batatas* (L.) by village pigs (*Sus scrofa papuensis*) in Papua New Guinea. 31(1-4): 69-72.

10. **Greve, J.E. van S. and Ismay, J.W.** (1983). Crop insect survey of Papua New Guinea from July 1st, 1969, to December 31st, 1978. 32(1-4): 1-20.

11. **Smith, E.S.C.** (1984). Results of three insecticide trials against cocoa podsuckers in the in the Northern Province. 33(1-2): 1-11.

12. **Young, G.R.** (1984). A checklist of mite and insect pests of vegetable, grain and forage legumes in Papua New Guinea. 33(1-2): 13-38.

13. **McGregor, A.J.** (1984). Control of Phytophthora seedling blight of cocoa. 33(1-2): 39-50.

14. **Clarkson, D. and Moles, D.J.** (1984). Effects of four fungicides on the growth of *Phytophthora colocasiae*. 33(1-2): 51-53.

15. **Sundberg, P. and Richards, A.** (1984). Deep-sea bottom handline fishing in Papua New Guuinea: a pilot study. 33(1-2): 55-62.

16. **Norris, K.R. and Owen, I.L.** (1984). *Muscidae (Diptera)* associated with cattle in Papua New Guinea. 33(1-2): 63-67.

17. **Humphrey, J.D.** (1984). Note on the prevalence and distribution of the eyeworm of the domestic fowl in Papua New Guinea. 33(1-2): 69-70.

18. **Smith, E.S.C.** (1985). A review of relationships between shade types and cocoa pest and disease problems in Papua New Guinea. 33(3-4): 79-88.

19. **Bourke, R.M.** (1985). Sweet potato (*Ipomoea batatas*) production and research in Papua New Guinea. 33(3-4): 89-108.

20. **Holmes, J.H.G.** and **Absalom, P.** (1985). Growth rates of Priangon crossbred sheep and some effects of internal parasitism, in the lowlands of Papua New Guinea. 33(3-4): 109-113.

21. **Gwaiseuk, W.R.J.** and **Holmes, J.H.G.** (1985). Intake digestibility and growth by tropical breeds of cattle consuming tropical grasses supplemented with mill run. 33(3-4): 115-121.

22. **Smith, E.S.C.; Thistleton, B.M.** and **Pippet, J.R.** (1985). Assessment of damage and control of *Helopeltis calvifer* (Heteroptera: Miridae) on tea in Papua New Guinea. 33(3-4): 123-131.

23. **Benjamin, C.** (1985). Some food market influences of a large-scale small-holder development in the West New Britain area of Papua New Guinea. 33(3-4): 133-141.

24. **Sutherland, J.A.** and **Bull, P.B.** (1985). Pollination and fruit set in two species of pumpkin in lowland Papua New Guinea. 33(3-4): 143-147.

25. **Street, J.M.** (1985). Book review (Climate of Papua New Guinea). 33(3-4): 149-151.

26. **Parfitt, R.L.** (1985). Book review (Soils of Papua New Guinea). 33(3-4): 153-154.

27. Williams, D.J. (1986). Scale insects tophthora seedling blight of cocoa. 33(1-2): 39-50.

14. Clarkson, D. and Moles, D.J. (1984). Effects of four fungicides on the growth of *Phytophthora colocasiae*. 33(1-2): 51-53.

15. Sundberg, P. and Richards, A. (1984). Deep-sea bottom handline fishing in Papua New Guuinea: a pilot study. 33(1-2): 55-62.

16. Norris, K.R. and Owen, I.L. (1984). *Muscidae (Diptera)* associated with cattle in Papua New Guinea. 33(1-2): 63-67.

17. Humphrey, J.D. (1984). Note on the prevalence and distribution of the eyeworm of the domestic fowl in Papua New Guinea. 33(1-2): 69-70.

18. Smith, E.S.C. (1985). A review of relationships between shade types and cocoa pest and disease problems in Papua New Guinea. 33(3-4): 79-88.

19. Bourke, R.M. (1985). Sweet potato (*Ipomoea batatas*) production and research in Papua New Guinea. 33(3-4): 89-108.

20. Holmes, J.H.G. and **Absalom, P.** (1985). Growth rates of Priangon crossbred sheep and some effects of internal parasitism, in the lowlands of Papua New Guinea. 33(3-4): 109-113.

21. Gwaiseuk, W.R.J. and **Holmes, J.H.G.** (1985). Intake digestibility and growth by tropical breeds of cattle consuming tropical grasses supplemented with mill run. 33(3-4): 115-121.

22. Smith, E.S.C.; Thistleton, B.M. and **Pippet,J.R.** (1985). Assessment of damage and control of *Helopeltis calvifer* (Heteroptera: Miridae) on tea in Papua New Guinea. 33(3-4): 123-131.

23. Benjamin, C. (1985). Some food market influences of a large-scale small-holder development in the West New Britain area of Papua New Guinea. 33(3-4): 133-141.

24. **Sutherland, J.A.** and **Bull, P.B.** (1985). Pollination and fruit set in two species of pumpkin in lowland Papua New Guinea. 33(3-4): 143-147.

25. Street, J.M. (1985). Book review (Climate of Papua New Guinea). 33(3-4): 149-151.

26. Parfitt, R.L. (1985). Book review (Soils of Papua New Guinea). 33(3-4): 153-154.

27. Williams, D.J. (1986). Scale insects (Homoptera: Coccoidea) on coffee in Papua New Guinea. 34(1-4): 1-7.

28. Arentz, F. (1986). A key to *Phytophthora* species found in Papua New Guinea with notes on their distribution and morphology. 34(1-4): 9-18.

29. D'Souza, E. and **Bourke, R.M.** (1986). Intensification of subsistence agriculture on the Nembi Plateau, Papua New Guinea. 1. General introduction and inorganic fertilizer trials. 34(1-4): 19-28.

30. D'Souza, E. and **Bourke, R.M.** (1986). Intensification of subsistence agriculture on the Nembi Plateau, Papua New Guinea. 2. Organic fertilizer trials. 34(1-4): 29-39.

31. D'Souza, E., Bourke, R.M. and **Akus, W.L.** (1986). Intensification of subsistence agriculture on the Nembi Plateau, Papua New Guinea. 3. Sweet potato cultivar trials: Crop rotation trials and crop introductions. 34(1-4): 41-48.

32. Muthappa, B.N. and **Bull, P.B.** (1986). Collar and root rot of aibika (*Abelmoschus manihot*). I: pathogenicity and effect of systemic fungicides. 34(1-4): 49-53.

33. Dalzell, P.J. (1986). The distribution and production of anchovies in Papua New Guinea waters. 34(1-4): 59-70.

34. Mahoney, D. and **Yamb, R.** (1986). Pathogenic bacteria isolated from chickens sold at the Lae market. 34(1-4): 71-75.

35. Abdelsamie, R.E. (1986). Effect of day-old debeaking and fowl pox vaccination on the performance of broiler chickens in Papua New Guinea. 34(1-4): 77-79.

36. Abdelsamie, R.E. (1986). A study of nutritional problems affecting the smallholder broiler industry in Papua New Guinea. 34(1-4): 81-84.

37. Owen, I.L. (1990). Blood parasites of cat-

tle in Papua New Guinea. 35(1-4): 1-11.

38. Abeyasekera, S. and **Nembou, C.S.** (1990). Rainfall analysis for improved agricultural planning. 35(1-4): 13-21.

39. Dalzell, P.J. and **Wright, A.** (199). Analysis of catch data from an artisanal coral reef fishery in the Tigak Islands, Papua New Guinea. 35(1-4): 23-36.

40. Lamothe, L., Arentz, F. and **Karimbaram, R.** (1990). Germination of cassowary egested and manually defleshed fruit. 35(1-4): 37-42.

41. Cox, P.G. and **Kasimani, C.** (1990). Control of taro leaf blight using metalaxyl: Effect of dose rate and application frequency. 35(1-4): 49-55.

42. Dwyer, Peter D. and **Minnegal, M.** (1993). Banana Production by Kubo People of the Interior Lowlands of Papua New Guinea. 36 (1): 1-21.

43. Gollifer, D.E. (1993). Effects of applications of mulch and potassium on *Capsicum annuum*. 36(1): 22-29.

44. Cragg, S.M. (1993). Wood break-down in mangrove ecosystems: A review. 36(1): 30-39.

45. Onaga, I.; Carrick, M. and **Owens, C.** (1993). Analysis of copper an dits status in cattle from Morobe Province, Papua New Guinea. 36(1): 40-53.

46. Gollifer, D.E. (1993). Fertilizer trials with tumeric (*Curcuma domestica* Val.) at Santa Cruz, Solomon Islands. 36(1): 54-59.

47. Sowei, J.W. and **Osillis, P.** (1993). Aibika (*Abelmoschus manihot*) germplasm in Papua New Guinea. 36(1): 60-69.

48. Kuniata, L.S. and **Young, G.R.** (1993). The use of chlorpyrifos in controlling weevil borer, *Rhabdoscelus obscurus* Boised. (Coleoptera: Curculionidae) in Sugarcane setts. 36(1): 76-78.

50. Moat M. and **Dryden, M.G.** (1993). Nutritive value of sweet potato forage (*Ipomoea batatas* (L.) Lam) as a ruminant animal feed. 36(1): 79-85.

51. Sillitoe, P. (1993). Soil and cultivation in the Papua New Guinea Highlands: I. Indigenous appraisal of the variable agricultural potential of soils. 36(1): 86-94.

52. Foy, T.J. (1993). Urbanization and the urban poor – Vanuatu's food security challenge. 36(1): 95-104.

53. Sillitoe, P. (1993). Soil and cultivation in the Papua New Guinea Highlands. II. A comparison of indigenous and scientific perspectives. 36(2): 1-21.

54. Onaga, I. (1993). The total mercury concentrations in fish from certain southern coastal waters and North Solomons Province of Papua New Guinea. 36(2): 22-28.

55. Majer, J.D. and **Queiroz, M.V.B.** (1993). Distribution and abundance of ants in a Brazilian subtropical coffee plantation. 36(2): 29-35.

56. Rolston, L.H.; Aalbu, R.L.; Murray, M.J. and **Rider, D.A.** (1993). A catalog of the *Tessaratomidae* of the world. 36(2): 36-108.

57. Evara, R. (1994). Working for a better tomorrow for agriculture in Papua New Guinea. 37(1): 7-8.

58. Caruthers, F. (1994). Management of agriculture sector in PNG economy. 37(1): 9-14.

59. May, R. (1994). Delivery of agricultural services in PNG: ADB's perspective. 37(1): 15-18.

60. Setae, M. (1994). Strategies and options towards the next decade – DAL views. 37(1): 19-24.

61. Menz, K.M. (1994). Pros and cons of agricultural research in developing countries – a prospect. 37(1): 25-29.

62. French, B.R. (1994). Technology assessment and transfer for sustainable agriculture and rural development – an FAO global view. 37(1): 30-31.

63. Sitapai, E.C.; Wayi, B.M. and **Ghodake, R.D.** (1994). The Papua New Guinea national agricultural research system: Its policy framework and development perspective. 37(1): 32-40.

64. Ihekoronye, A. (1994). Meeting the developmental challenges of the livestock industry in Papua New Guinea. 37(1): 41-43.

65. Bakau, B.J.K. and **Galgal, K.K.** (1994). Livestock research and development in Papua

New Guinea. 37(1): 44-48.
66. **McKillop, B.** (1994). Extension performance managemen: International trends for the 1990s. 37(1): 49-55.

67. **Bakani, F.** (1994). Reorganization of agricutural extension services in Papua New Guinea. 37(1): 56-67.

68. **Daur, L.** (1994). Agriculture extension services in Madang. 37(1): 68-70.

69. **Mopafi, I.** (1994). Agriculture extension sevices in Madang. 37(1): 71-72.

70. **Hamou, K.** (1994). Agricultural extension services in Manus Province. 37(1): 73-83.

71. **Gumoi, M.** (1994). The role of price subsidies in agriculture in Papua New Guinea. 37(1): 8491.
72. **Fernando, N.** (1994). Improving rural institutional finance: Some lessons. 37(1): 92-103.

73. **Kannapiran, C.** (1994). Sustainable rural credit for agricultural development in PNG. 37 (1: 104-116.

74. **Longimire, J.** (1994). Marketing systems for agriculture: Diagnosing problems and price and market analysis for Papua New Guinea. 37 (1: 117-132.

75. **Mangila, F.** (1994). Proposed Market Research and intelligence Service Branch. 37(1): 133-138.

76. **Ivess, R.J.** (1994). Quarantine – a client oriented approach. 37(1): 139-146.

77. **Kanawi, D.; Bannick, A.** and **Kula, G.** (1994). The process of quarantine in PNG and it's present status. 37(1): 147-151.

78. **Jones, A.** (1994). The development of snal-scale food processing enterprises. 37(1): 152-162.

79. **Pondikou, P.** (1994). Human resource development in agriculture sector – DAL's projections. 37(1): 163-167.

80. **Hua, H.T.** (1994). Agricultural information aid publication systems and services. 37(1): 168-173.

81. **Erai, H.** and **Kumar, R.** (1994). Agricultural Information and Publication systems and Services (AI&PSS) suitable for PNG needs. 37 (1): 174-177.

82. **Kaptigau, J.** (1994). Resolutions and recommendations arising from the consultative Seminar. 37(1): 178-180.

83. **Camarotto, C.** and **Bourke, R.M.** (1994). Potential for exporting fruit from Papua New Guinea to overseas markets during their off-seasons. 37(2): 2-13.
84. **Rodoni, B.C.; Dale, J.L.** and **Harding, R.M.** (1994). Review of alomae disease of taro. 37(2): 14-18.

85. **Sajjad, M.S.** (1994). Comparative study on ratooning potential of standard rice varieties of PNG. 37(2); 19-22.

86. **Dowling, A.J.; Konabe, B.** and **Tigat, R.** (1994). Nutritional assessment of steeply sloping soils from Aiyura in the Eastern Highlands of Papua New Guinea. 37(2): 23-29.
87. **Smith, E.S.C.** (1994). Notes on two minor insect pests in the Highlands region. 37(2): 30-35.

88. **Kuniata, L.S.** and **Nagaraja, H.** (1994). Insects of the giant sensitive plant (*Mimosa invisa*) at Ramu, Papua New Guinea. 37(2): 36-39.

89. **Pitala, J.A.** and **Sivasupiramaniam, S.** (1994). Effects of goat manure, NPK-fertilizer, insecticides and fungicides, and compost on potato yield at the Yasubi Rural Extension Centre. 37(2): 40-46.

90. **Kuniata, L.S.** (1994). *Cordyceps* sp. An important entomopathogenic fungus of cicada nymphs at Ramu, Papua New Guinea. 37(2): 47-52.

91. **Philemon, E.C.** (1994). An overview of the pathology of genus *Colocasia*. 37(2): 53-61.

92. **Wagih, M.E.** (1994). Fiji disease virus of sugarcane: A review of techniques for its diagnosis and elimination from tissue culture and planting materials. 37(2): 62-66.

93. **Gibson, J.** (1994). The price elasticity of demand for Papua New Guinea exports of cocoa and coffee. 37(2): 67-75.

94. **Laup, S.** (1994). Pests and diseases of shade trees and their relation to cocoa in Papua New Guinea. 37(2): 76-85.

95. Toreu, B. (1994). Survey results for PNG cocoa bean quality factors. 37(2): 86-93.

96. Konam, J.K. and **Waine, W.** (1994). The current status of the pink disease (*Corficium salmonicolor*) of cocoa in Papua New Guinea. 37(2): 94-99.

97. Dowling, a.J.; Blamey, F.P.C. and **Hoa, T.** (1995). Limitation to Sweet Potato growth in small volumes of soil imposed by water and nutrient stress, acidity and salinity. 38(1): 2-10.

98. Akus, W.L. and **Nema, R.K.** (1995). Evaluation of twenty five vegetable varieties at Aiyura, Eastern Highlands Province. 38(1): 11-16.

99. Akus, W.L. (1995). Evaluation of introduced sweet potato cultivars at Aiyura in the Eastern Highlands of Papua New Guinea. 38 (1): 17-21.

100. Sajjad, M.S. (1995). Development of modern upland rice (*Oryza saliva* L.) varieties with superior milling and physicochemical trials, for Papua New Guinea. 38(1): 22-30.

101. Ivancic, A.; Simin, A.; Ososo, E. and **Okpul, T.** (1995). Wild Taro (*Colocasia esculenta* (L.) Schott) populations in Papua New Guinea. 38(1): 31-45.

102. Amoa, B.; Dekuku, R. Chris and **Nigo, R.Y.** (1995). Consumer preference of some rice varieties grown locally in Papua New Guinea. 38(1): 46-50.

103. Roth, Louis M. (1995). New species of *Allacta, Saussure* and *Zehhntner* from Papua New Guinea, Irian Jaya and Sarawak (Blattaria, Blattelidae: Pseudopgylodrominae). 38(1): 51-71.

104. Sowei, J.W. (1995). Onion cultivar selection for the lowlands of Central Province. 38 (2): 76-83.

105. Louman, B.; Hasagama, M.; Bigol, C. and **Gamuna, P.** (1995). Regneration and residual stand after wokabaut somil operations in seasonally inundated forest near Lae, Papua New Guinea. 38(2): 84-93.

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236. Kasi, G., Akanda, S., (2009) Screening of five elite sweet potato cultivars against reniform nematode (Rtylenchulus reniformis) under humid and semi-arid conditions of Papua new Guinea. 52 (1&2) 25-36

237. Iko, M., Akanda. S., Komolong, B. (2009) Investigation of Peanut Stripe Virus Disease at Markham-Ramu Valley in Papua New Guinea. 52 (!&2) 37-43

238. **Lobao, Martin** and **Quartermain, Alan.** (2011) Feeding Rabiits on Locally available feeds in Papua New Guinea. 53 (!&2) 03-08

239. **Ignatius. Saun.** (2011) Feeding Muscovy Ducks onLocally avaialbe Agro-Industral by Products and Feed Resources. 53 (!&2) 09-13

240. **Kurika, K., Kawi, A.,C., Dewhurst.C., Waisale, Serah., Maora. S. J., Fidelis, J., Boksou.J., Moxon, J., Orapa. W., and Day. Michael.** (2011) Mile-A-Minute (Mikania Micranth): Its distribution, Growth and Physcial and Socio-Economic Impacts in Papua New Guinea. 53 (1&2) 15-18.

241. **Pitala. Joachim., A.R. (2011)** Advancing Papua New Guinea 's Food Production through the use of inorganic or mineral fertilizers: A Personal perspective. 53 (1&2) 19-26

243. **Kuman, Noel, Y.** and **Hollywood Neil.** (2011) The critical Nature of Anaerobic Phase in Cocoa Microfermentation methods tor reproduce optimum cooca flavour similar to large

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244. Kuman., Noel., Y. and **Hollywood, Neil**. (2011) Developing a New Small-Scale laboratory Microfermentation methods that can successfully ferment small quantities of Cocoa for a rapid and Reliable Genotype flavour profiling. 53 (!&2) 31-34.

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246. Malangen Stanis .(2011) Tiller Dynamics in Indica and Tropical Japonica Rice from Transplanting Stressed seedlings under irrigated conditions. 53 (!&2) 43-49.

247. Quartermain, Alan R. (2011) Intensive Livestock Production: Lessons learned and future prospects. 53 (!&2) 51-54.

248. Jambui, M.I. and Quartermain A.R. (2013) Effect of Genotype, Age of layer and their Interaction on Egg Quality Characteristics of Egg-Lay Chickens. 54 92011/2012): 3-9

249. Gariba Danbaro, S. Zhao and J. Han. (2013) Identifying Populations of Papua New Guinea's Indigenous Chicken for priority Conservation. 54 (2011/2012): 03-09

250. Stanis Malangan, Toru Hata, Takumi Iwakura, Katsuya Nakmura and Masayuk Mural. (2013) Panicle Characteristics in High-yielding japonica Rice lines carrying Ur 1 (undulated rachis-1) Gene.54 (2011/2012); 11-18

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254. Haron Jeremiah and Ruth Turia. (2013). Effect of Hot Water Pre-treatment, Light and Storage on Germination of Scheinitzia Novoguinensis Verd Seeds. 54 (2011/2012); 45-49.

AUTHOR INDEX

SUBJECT INDEX

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6. Headings - In experimental papers the general order of headings is: Abstract, Introduction, Materials and Methods, Results, Discussion, Acknowledgements, References, Appendix. In descriptive, or other types of papers, as far as possible, a similar format should be followed. No headings should be underlined.

7. Text - Papers should be concise. Extensive introductions referring to the work of earlier authors should be avoided. Lengthy discussions and detailed descriptions should be reduced by the use of tables and diagrams. The text should not repeat in detail what is apparent from a table or diagram.

Names of countries or organizations may be abbreviated to capitals without full stops but must be given in full at the first mention.

Numbers under 11 should be spelt out unless qualifying a unit of measurement. If a number over 10 and a number under 11 appear in the same sentence, both are written as numerals. Do not begin a sentence with a numeral. Fractions should be given as decimals or spelt out. All decimal numbers less than unity should have a zero before the decimal marker, e.g. 0.25. All units should be in the S.I. System.

All scientific names of animals and plants must be underline to indicate that they should be set in italic type or written in italics. The authority should be cited in full on the first occasion a scientific name is used. Where the same name is used repeatedly, the genus may be abbreviated to a capital letter after the first citation. For example, use *Homo sapiens* Linnaeus on the first occasion and *H. sapiens* thereafter.

Common or local names may be used but the scientific name should be quoted on the first occasion. An agricultural chemical must be referred to by its generic or common name when it is first quoted.

8. Tables - Numerical results should be displayed as means with relevant standard errors rather than as detailed data. Standard errors should be given to one place of decimals more

than the means to which they refer and the number of degrees of freedom should also be quoted. Tables should be complete in themselves so that they can be understood without reference to accompanying text. Each table should have a brief and self explanatory title. The presentation of the same data in tabular and graphic form is not permitted.

9. Figures and photographs - Line drawings should be drawn in black water-proof ink on smooth tough paper. Labeling should be clear and always produced with stencils using black water-proof ink and should be legible when reduced. No alterations or additions to artwork can be made by the editors. Figures should be no larger than an A3 page, and no smaller than final published size. Photographs should be glossy prints of good quality and must make a definite contribution to the value of the paper. Indicate the top of the figures and photographs on the back: the plate number of each figure and photographs, the author's name, and the title of the paper. Do not write on the back of photographs: use an adhesive label with the data previously written on it. Artwork should be of appropriate proportions for the final dimensions.

10. Acknowledgements - The names, initials and place of work of those the author wishes to mention may be included. It is unnecessary to mention everyone who has been marginally involved in the work.

11. References - These should be cited in the text by the author's name and data as follows:

"Moran and Brown (1965) showed or "Various works" (Miller and Smith 1956; Adams *et al.* 1960; Wilson 1978, 1979 a) found ..." The term *et al.* should be used when there are more than two authors. The letters a,b,c, should be used to distinguish several papers by the same author in one year.

All references in the bibliography should be given in full and in alphabetical order. For a journal the reference should include surname and initials of all author(s), (year), title of paper, full title of the journal, volume, (part) and full page numbers. For a book the reference should include author(s) surnames and initials, (year), title of chapter and page numbers if appropriate, full title of book, published and city and total page numbers. Conference proceedings should include the year and place of the conference. The title of the journal or book is underlined to be printed in italics. Examples:

Bowet, C.M. and **Smith, L.N.** (1950). Measurement of phosphorus. *Methods of Soil Analysis*. C.A. Lack. Ed. Department of Primary Industry, Port Moresby.

Sanders, A.J. (1940). Plant responses to Molybdenum. *Papua New Guinea Agricultural Journal* 48(4): 981-995.

Troben, M.M. (1973). Genetic fine structure in *Drosophila. Department of Primary Industry Research Bulletin* No. 102: 196-197.

Vance, P.N. (1976). Maize in the Markham Valley. Pp. 215-220. *In: 1975 Papua New Guinea Food Crops Conference Proceedings.* K. Wilson and R.M. Bourke (Ed.). Department of Primary Industry, Port Moresby.

Internal reports, communications and memoranda are not valid references. The criteria for valid publications (in the scientific world) are that publications are distributed widely among those interested in the subject and are available to the international public in major libraries and from the publisher. This therefore excludes reports circulated only within a department and to a few outsiders and conference documents available only to those who attended the conference and the like.

Work that has not been accepted for publication (unpublished data) and personal communications are not included in the list of references but may be refereed to in the text. References cited in an appendix should be included in the list of references at the end of the paper.

Special care should be take to see that every reference in the text is included in the list of references and vice versa, and that there is consistency in the spelling of author's names and the citation of the dates throughout the paper.

12. Review of papers - All papers will be submitted to suitable professional referees. Major changes will be referred to the author for consideration. Minor editorial changes will be made without consultation but will be presented to the author(s) at proof stage. The final decision to accept or reject a paper, rests with the Editor.

13 Offprints - Twenty-five free off-prints are given to the author. Where there are several authors, the first author will be sent the off-prints. Extra off-prints may be ordered at the time the galley proofs are returned to the editor.

Costs will be determined at the time of printing.

14. Recognised abbreviations in this journal are:

g - gram
kg - kilogram
t - tonne
l - litre
ml - millilitre
ha - hectare
mm - millimetre
cm - centimeter
M - metre
a.s.l. - above sea level
yr - year
wk - week
h - hour
min - minute
s - second
k - kina
n.a. - not applicable or not available
n.r. - not recorded
var - variance
s.d. - standard deviation
s.e.m.- standard error of difference
d.f. - degrees of freedom

Levels of significance

n.s. - not significant
* - 0.01 $p < 0.05$
** - 0.001 $p < 0.01$
*** - $p < 0.001$

Either kg/ha or kg.ha is acceptable, but large combinations of units should be in the form kg.ha to avoid possible mathematical ambiguity.

15. Submission of manuscripts - All correspondence should be addressed to: Editor, PNG Journal of Agriculture, Forestry and Fisheries, Agricultural Information Branch, Publication Section, Department of Agriculture and Livestock, P.O. Box 2033, Port Moresby, Papua New Guinea or e-mail to dalit@daltron.com.pg and chrisdekuku@yahoo.co.uk