Appendix 2
On-farm and on-station productivity research

The detailed reports included within this Appendix refer to the research activities undertaken within Objective 2 of the project. Each Activity Report is structured in the format of a scientific report where possible, with an introduction, description of the methods used, findings and conclusions and/or recommendations. The specific Activity Reports contained within this Appendix include:

Activity 2.1. Monitor on-farm cattle production and management

Prepared by: Simon Quigley

Introduction

Increasing cattle production is one potential pathway to improve the livelihoods of rural households across Vanuatu. Approximately 25% of all households (14,000 out of a total of 55,500 households) in Vanuatu raise beef cattle (VNSO, 2016). Approximately 95% of these households (13,200) are considered smallholders raising between 1 to 20 cattle (VNSO, 2016).

The production systems are typically low-input / low-output, which are biologically inefficient, but can be resource use efficient. Cattle almost exclusively free-graze land held under customary tenure, with the exception of some tethering of cattle which typically occurs during weaning. Stall or lot feeding, cut-and-carry, and supplementation of cattle are not practiced in Vanuatu and cattle are not used for draught. More productive land, where available, is used for the production of staple (taro, yam, cassava, island cabbage) and cash crops (kava, copra, coffee, cocoa) by smallholder households. Previous reports indicated the majority of Vanuatu's cattle free-graze on some 105,000 ha of land, comprising of 50,000 ha of open grasslands, 45,000 ha under copra, and 10,000 ha under trees, from a total land area of 1,200,000 ha (MacFarlane, 1998). MacFarlane (1998) reported the remaining land area consisted of 900,000 ha of native and plantation forests (75% of total land area) and 115,000 ha (approximately 10% of total land area) was fallow or unusable, leaving only 15% of the total land area for grazing, food production, and other tree crops. There is limited information on the area of land currently used or potentially available for cattle grazing across Vanuatu.

Information on existing cattle productivity in smallholder systems is extremely limited, with no published references identified in literature searches. Data generated and reported by the Vanuatu Pasture Improvement Program (1994) is largely relevant to the larger plantations where significant pasture improvement programs may be implemented. Other relevant data is derived from previous industry analysis (Cardno, 2014; NZ MFAT, 2017). From these sources the major biological constraints to increased cattle production in Vanuatu include a high weed burden, low pasture biomass availability, and limited drinking water, resulting in low reproduction rates (50% calving rate) and low liveweight gain. A further, and perhaps more significant constraint to increasing the productivity of cattle production in Vanuatu is the lack of a market-based incentives to commercialise and specialise cattle production systems, with prices for cattle low by global standards (see Section 3). Other societal and cultural factors also undoubtedly influence the decisions households make regarding their cattle production systems (Section 1).

Cattle in Vanuatu are considered free of the OIE (World Health Organisation for Animal Health) notifiable diseases, with foot-and-mouth, rinderpest, blue tongue, akabane, and ephemeral fever all absent. Brucellosis and tuberculosis were detected in the late 1960s and early 1970s with successful eradication of tuberculosis conducted in the 1970s and 1980s (Schandevyl and Deleu, 1985). Brucellosis has not been reported since the early 1990s (Brioudes, 2016). Struthers and Troost (1998) reported a high incidence of leptospirosis but otherwise there is a relatively disease and parasite free status amongst the cattle herd. Ticks occur at a very low incidence rate and tick-borne diseases are absent. Internal parasites are often locally associated with cattle in low body condition or low liveweight gain, however there is little evidence to support this. Brioudes (2016) indicated reports of bovine venereal campylobacteriosis (Vibrio) and various sources suggest that an AusAID funded vaccination program was undertaken during the 2000s with some success. However, no reports or data has been accessible regarding either the impetus for, or impact of, this program. Local information suggests that vaccination all but ceased once the program and funding concluded, with the exception of possibly one large commercial operator.

Accurate local data is required to develop sound evidence-based recommendations for farmers and policy makers regarding the main constraints and opportunities for the cattle sector in Vanuatu. The objective of this activity was to describe the existing cattle production systems in the East Santo Area Council through field based data collection (including both animal monitoring and farmer surveys) and to identify low / no-cost management strategies to increase the productivity and profitability of cattle production systems in Vanuatu.

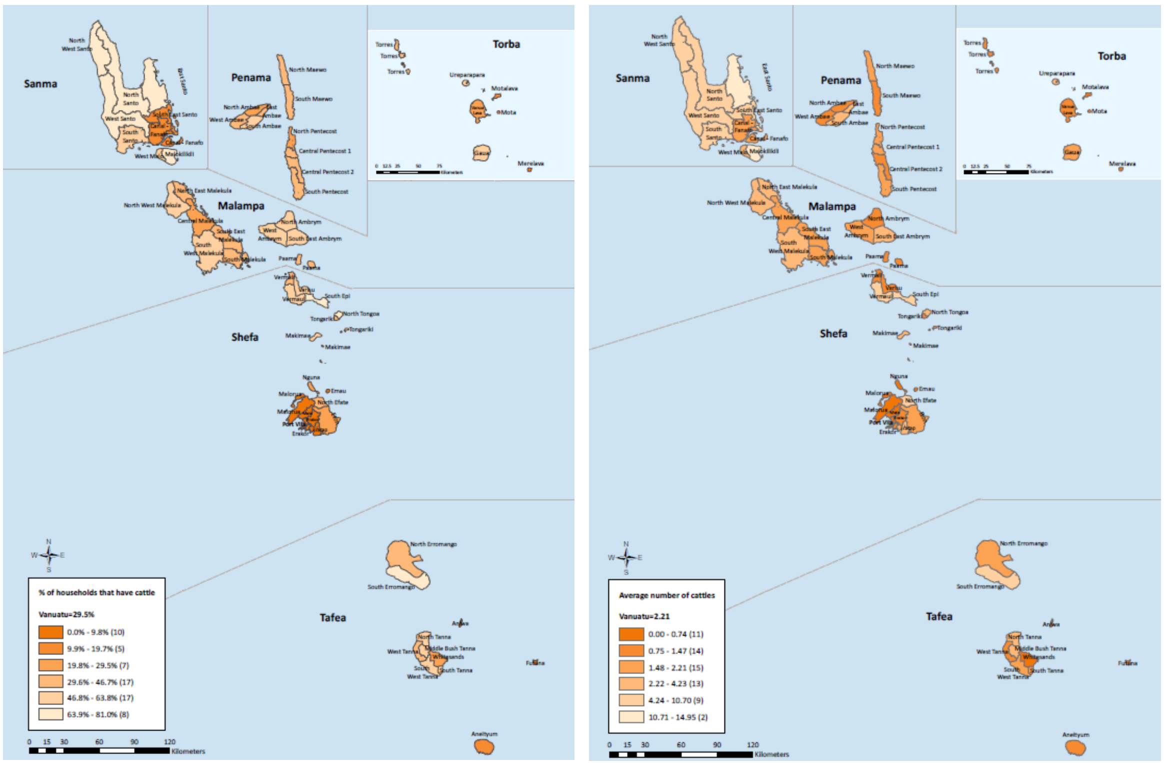
Materials and methods

All procedures used in this experiment were conducted under the guidelines of the Australian Code of Practice for the Care and Use of Animals for Scientific Purposes and were reviewed and approved by the University of Queensland Animal Ethics Committee.

Location

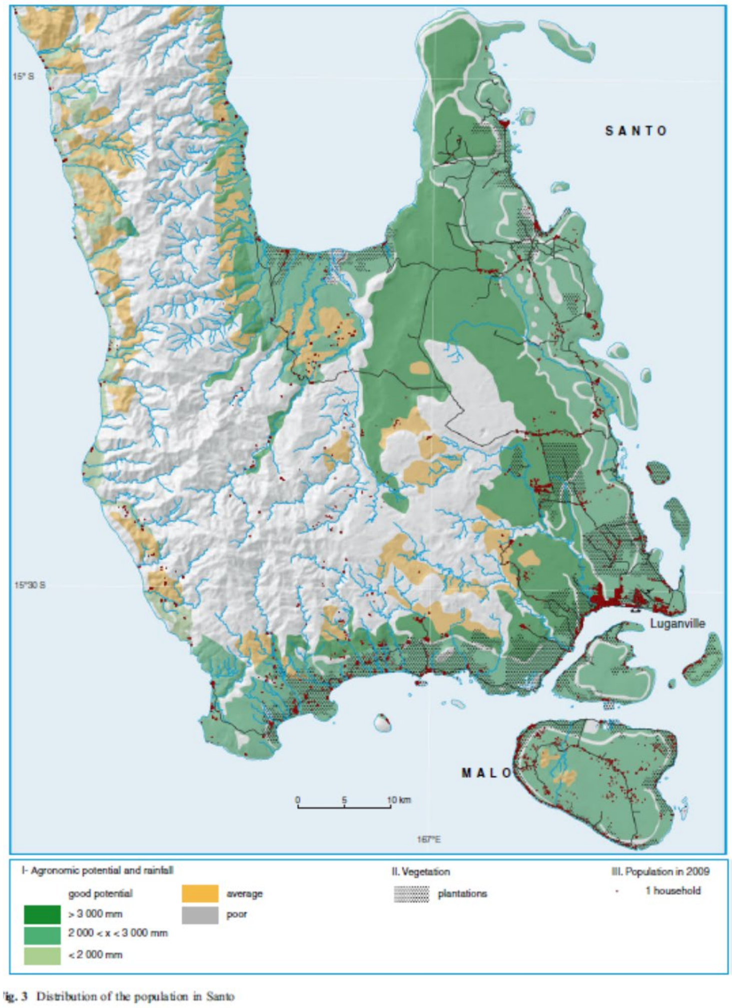
Longitudinal monitoring of cattle production was conducted within the East Santo Area Council (60,700 ha) on the island of Espiritu Santo (Santo; 407,000 ha) in SANMA province (comprising the islands of Santo, Malo and Aore) of Vanuatu (Figure A2.1). The study location was selected by the project team based on census data available at the time (VNSO, 2016) which indicated East Santo Area Council had a large number of smallholder households (686; ~75% of all households in East Santo Area Council) rearing cattle (Figure A2.2) within biophysical systems that were likely to be reflected elsewhere in Vanuatu [i.e. cattle under copra plantations, cattle in (semi-cleared or improved) bush]. Approximately 37% of the national cattle population are located in SANMA province with approximately 8% of the national cattle herd located in East Santo (9450; ~14 cattle/household) (VNSO, 2016). Within East Santo Area Council, the project concentrated on smallholder farms within three main village areas of Khole (n=12 households), Sara (n=23 households), and Port Olry (n=16 households), which represented coastal, upland, and drier regions within the Area Council respectively (Figure A2.3). Additional households (n=7) from surrounding villages (Natawa, Pene, Hog Harbour) participated in some activities. In addition to existing numbers of households and cattle, smallholders on Santo have access to many market options (two abattoirs, urban and rural butcheries, inter-island trade, large-holder farmers, and a large ceremonial market) and large areas of land classified as ‘Good’ available for further development for agriculture, plantations, and pastures (Quantin, 1982; Simeon and Lebot, 2012).

Figure A2.1. Map of area councils on Espiritu Santo, Vanuatu. (Source: City Population)



a. b.

Figure A2.2. Proportion of households rearing cattle (a.) and average number of cattle per household (b.) in Area Councils across Vanuatu. (Source: VNSO, Population and Housing Census, 2009)



a.

b.

Figure A2.3. Distribution of households and plantations (a.) and location of Khole, Sara and Port Olry villages, East Santo Area Council (b.). (Source: Simeoni and Lebot, 2012; GoogleEarth).

Description of cattle farming households and classification of cattle farming systems

A detailed description of the households, their resources, and livelihoods objectives are provided elsewhere in the report (Appendix 1).

The project initially developed a typology of cattle farming households in East Coast Santo from which a small number of households (approximately six from each typology) would be invited to participate in an intensive longitudinal monitoring of herds (Table A2.1).

Table A2.1. Proposed typology of cattle farmers in East Santo (bold, italicised text indicates the vast majority of cattle farming typology).

<table>
<tr><th>Parameter</th><th colspan="5">Indicator</th></tr>
<tr><td>Village</td><td>Khole</td><td colspan="2">Sara</td><td colspan="2">Port Olry</td></tr>
<tr><td>Land tenure</td><td>Customary</td><td colspan="2">Other</td><td colspan="2">Other</td></tr>
<tr><td>Production system</td><td>Copra plantations</td><td colspan="2">Bush systems</td><td colspan="2">Copra and bush</td></tr>
<tr><td>Enterprise</td><td>Cow-calf</td><td colspan="2">Fattening</td><td colspan="2">Both</td></tr>
<tr><td>Herd size
(total cattle number)</td><td>Small
(1 to 20)</td><td colspan="2">Medium
(21 to 100)</td><td colspan="2">Large
(> 100)</td></tr>
<tr><td>Cattle related farm infrastructure</td><td>Fencing</td><td colspan="2">Stockyard</td><td colspan="2">Water supply</td></tr>
<tr><td>Other income sources</td><td>Private transport</td><td>Kava</td><td>Copra</td><td>Coffee</td><td>Cocoa</td></tr>
<tr><td>Social and cultural obligations</td><td colspan="2">Yes</td><td colspan="3">No</td></tr>
<tr><td>Women involved in cattle farming</td><td colspan="2">Yes</td><td colspan="3">No</td></tr>
</table>

It became evident that the majority of households could be categorised by similar parameters. Therefore an alternative approach to describe farming households by the land resource condition under which cattle grazed was proposed, which indirectly reflected the level of management implemented (Figure A2.4). Farms were defined as:

1. Cattle under copra plantation – heavily weeded (n=5 households; Copra_weeds),
2. Cattle under copra plantation – overgrazed (n=19 households; Copra_overgraze),
3. Cattle under copra plantation – well managed (n=13 households; Copra_well),
4. Cattle in semi-cleared bush (n=14 households; Unimproved_bush), and
5. Cattle in cleared/improved bush (n=7 households; Improved_bush).


Cattle under copra - heavy weed ingress


Cattle in unimproved bush


Cattle under copra - overgrazed


Cattle in improved bush


Cattle under copra – well managed

Figure A2.4. Classification of cattle farming systems the project worked within in East Santo Area Council.

Procedures

Rainfall

Rain gauges were established in schools within each of three villages to collect localised rainfall data which is largely non-existent at this point in time. Teachers and students were provided with a template for data collection and graph paper for plotting monthly rainfall. Data was collected from each school by the project team every 2 to 3 months.

Soil profile

Soil samples were collected from the upper 0 to 15 cm, from eleven different locations across eastern Santo (Figure A2.5). Samples were imported into Australia for analysis under permit and released from quarantine after irradiation at 50 kGy. Samples were analysed at a commercial laboratory for a full soil profile. The effect of gamma irradiation on a diverse range of assays and sample types has previously been tested and confirmed that 50 kGy of gamma has no effect on the parameters of interest in feed, faeces, and blood samples, and this was assumed to be consistent for soil samples.

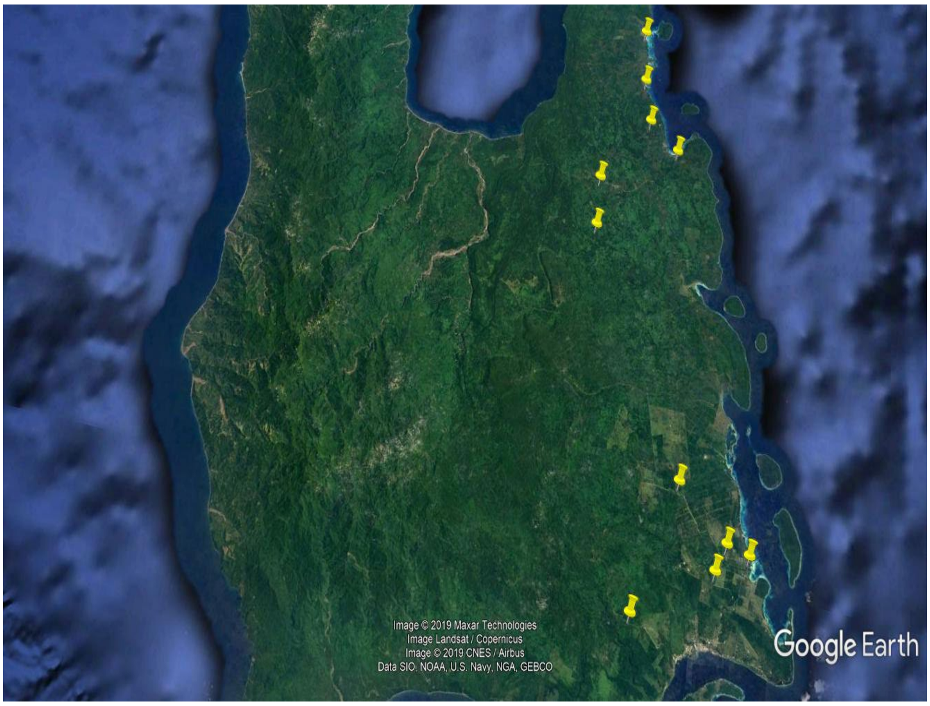


Figure A2.5. Soil sample locations, eastern Santo. (Source: GoogleEarth).

Farm area

The fenced perimeter of participating farms was walked with a handheld GPS unit (Garmin) and the area in ha calculated with tracks imported into Google Earth. Maps were printed and provided to farmers with area calculations. Whilst providing essential farm level information for researchers, this was a key engagement tool for farmers who largely had little awareness of their land area. This knowledge can assist with farm planning (subdivision, stocking rate, labour allocation) or land distribution decisions amongst family members. Cattle grazing area classification was conducted on each monitoring visit.

Cattle monitoring

Longitudinal monitoring was undertaken by a team of two field researchers on most occasions, with assistance from students from the Vanuatu Agricultural College and other project team members (including a volunteer for a period of time) occurring on an *ad hoc* basis. Measurements were conducted at the start (May to July; Round_1, R_1) and end (October to November; Round_2, R_2) of the dry season each year (assumed to be on average a 210 day wet season and 155 day dry season). Pilot testing of monitoring systems commenced in October-2016, with final monitoring occurring in July-2019 (i.e. 2.5 years of monitoring data across six monitoring events).

Farmers were required to have basic cattle handling facilities for holding cattle, whilst the project used a mobile cattle crush, portable panels, and cattle scales to conduct measurements. Individual cattle were allocated the same unique identification number in each ear. Monitoring included liveweight, body condition score, lactation status, and any management practices (weaning, sales). A portable crush (Figure A2.6) allowed for safe animal best-practice husbandry to be undertaken (dehorning, castration). Cattle were maintained under the prevailing management conditions throughout the monitoring period. This typically involved free-grazing of unimproved fenced lands with little segregation of herds; a small number of farmers segregated cow-calf and fattening systems on different blocks of land (e.g. copra and bush respectively). Households typically maintained small plots of land near houses for staple and cash crops, with these secured to prevent crop damage by cattle. Cattle were generally maintained with no inputs [e.g. no supplementary or improved feeding, no animal health treatments and with the exception of weaning, no strategic management of cattle classes (e.g. creep feeding and controlled mating were not practiced)]. The extensive nature of the production systems meant that accurate data capture was an ongoing challenge for the research team.

a.

b.

Figure A2.6. Portable cattle crush transported into a farm, Khole village (a.) and set for monitoring, Port Olry (b.).

For each of the three monitoring years, animals were identified as calves (born within the year of measurement and/or less than 160 kg liveweight), heifers (females that were greater than 12 months of age or 160 kg liveweight that had not yet given birth), cows (females that were greater than four years of age, lactated at least once during the monitoring period), steers (any castrated male greater than 160 kg liveweight), and bulls (any entire male greater than 160 kg liveweight) at each liveweight measurement event. A single animal unit (AU) was considered a non-lactating cow (450 kg liveweight); lactating cow-calf = 1.6 AU; heifer/steer = 0.6 AU; mature bull = 2 AU.

Given the low numbers of cattle presented at consecutive measurements or remained in the sites throughout the monitoring period, simple descriptive data (mean and number of replicates) are presented only, with no statistical analysis of the data being undertaken. Given the low number of animals monitored at each of the sites the results should be viewed with caution.

Faecal collection and analysis

Mob level faecal samples were collected from the same (nine) farms each month over 12 (faecal egg counts; FECs) or 24 (faecal near infrared spectroscopy; F.NIRS) months. Eight of the farms represented the five cattle farming classifications identified above. Samples were also collected from a large plantation on which cattle grazed on improved signal grass based pastures with local legumes (resulting in nine farms in total; Figure A2.7). For each mob, samples were collected from 10 to 15 individual fresh faecal deposits per month, mixed thoroughly and sub-sampled for FECs and F.NIRS.

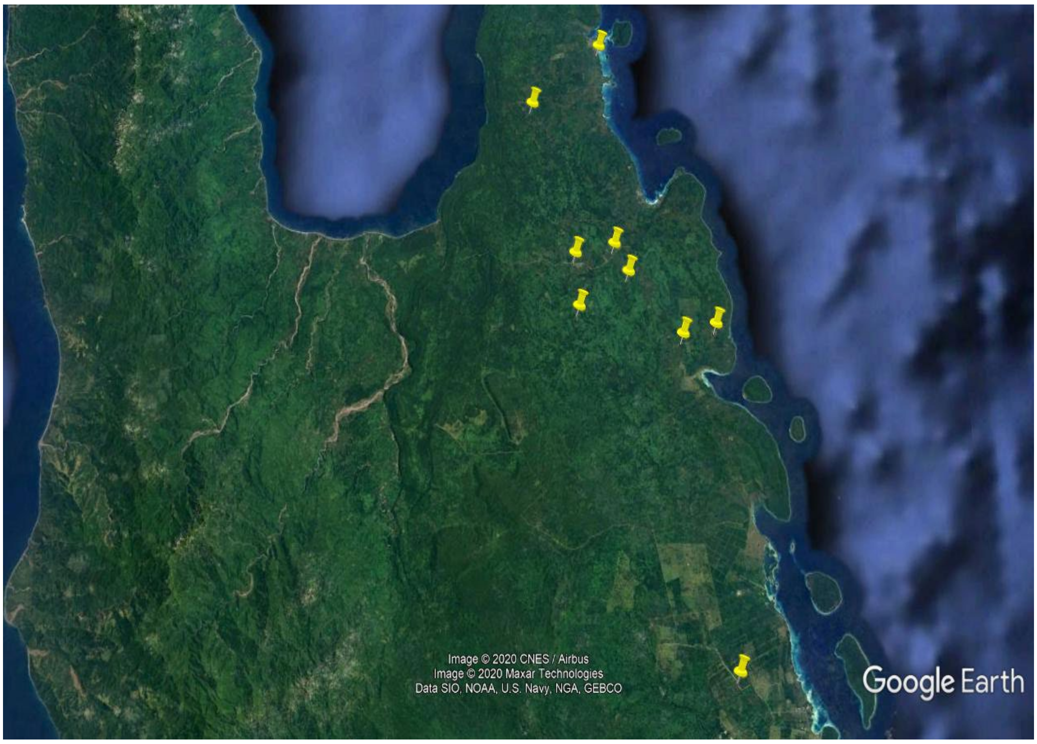


Figure A2.7. Location of farms in East Santo Area Council for monthly faecal collections. (Source: GoogleEarth).

For FECs, a 20 g sample was kept cool and shipped by plane to the Department of Livestock, Tagabe, Port Vila. Fresh faeces (4 g) was mixed with 26 mL of saturated salt solution and transferred to a counting chamber on a McMaster slide with strongyl eggs enumerated under a microscope and the presence of eimeria oocysts recorded.

For F.NIRS, samples from each herd were dried to a constant weight at 60^{o}C and crumbled before being imported to Australia under permit. Samples underwent gamma irradiation at 50 kGy prior to release from quarantine. Samples were ground through a 1 mm screen using a FOSS grinder (ZM200; Haan, Germany) and dried at 60^{o}C for 24 h to remove residual moisture. Samples were placed in a desiccator for 1 h to equilibrate to room temperature prior to NIRS analysis. Samples were scanned in a FOSS monochromator (6500; NIRS systems, Hillerod, Denmark) and the NIR spectra were recorded across the range 750 to 2500 nm using winISI SCAN software (Infrasoft International, Port Matilda, Penn.). Calibration equations developed for cattle in northern Australia were used to predict the dietary crude protein content, dry matter digestibility, and the proportion of non-grass within the diet consumed by cattle for each scanned faecal sample (Coates, 2004).

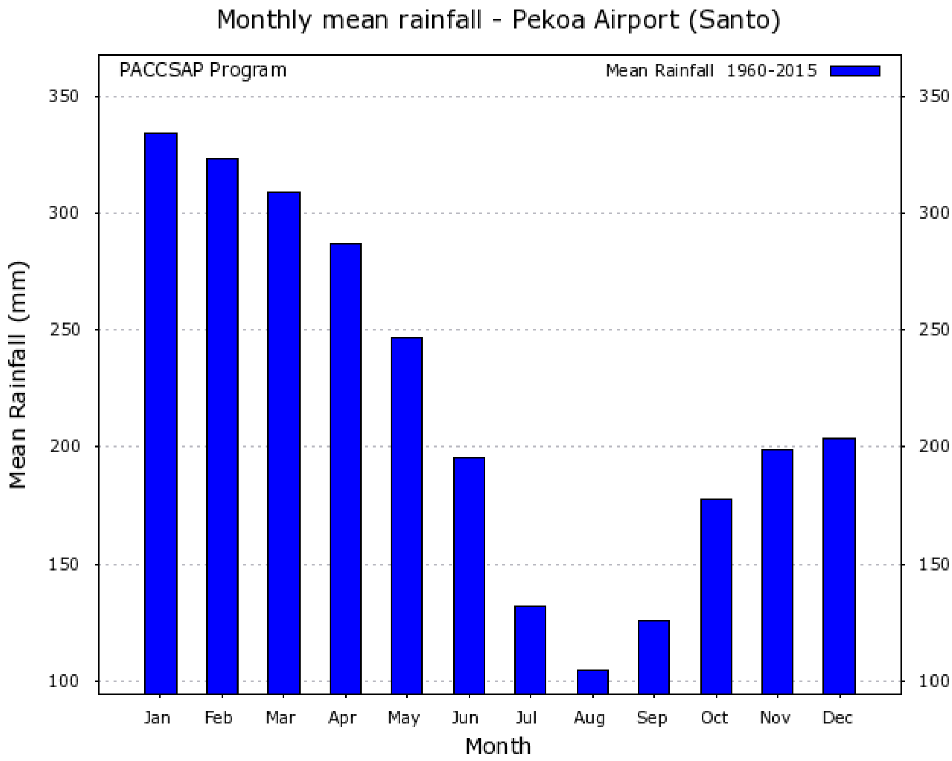
Data collection

Quantitative data was collected in CommCare software (Dimagi) installed on handheld devices (Samsung). Digitally collected data included animal, farm, and household level measurements and surveys. Animal level data was printed and provided to farmers on the day of monitoring (near real-time), which included some management recommendations (e.g. wean for any lactating cows in body condition score less than 2.5; cull unproductive females that were not lactating and had not lactated for over 18 months) or an estimated value through the SMP and WSS abattoirs based on measured liveweight, estimated dressing percentage, and current price schedule for the different classes of cattle.

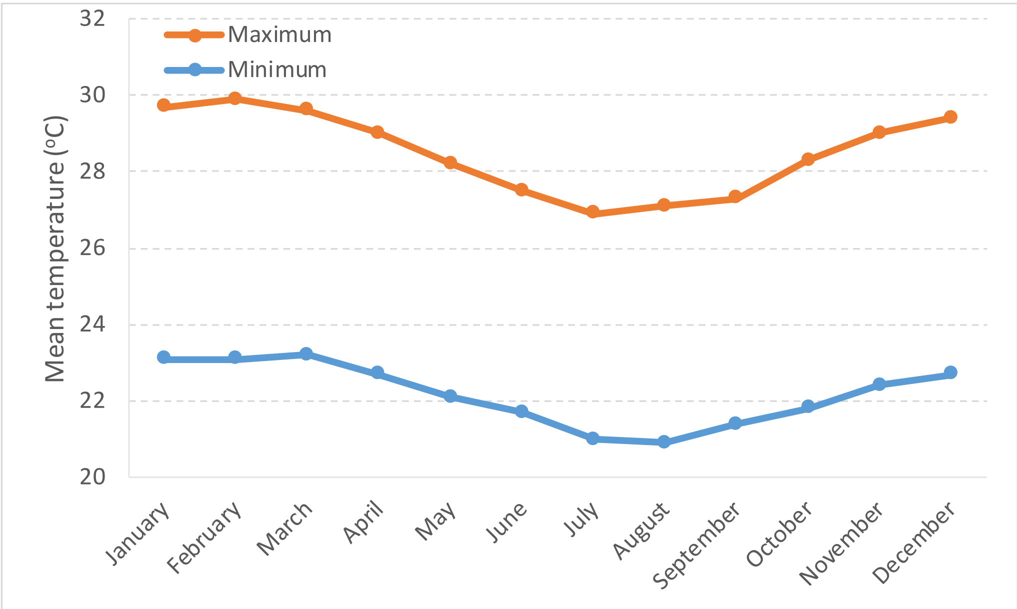
Results and discussion

Rainfall

Historical rainfall data from the Pekoa (15.52°S, 167.22°E) weather station (BOM 2020) located in the southeast corner of Espiritu Santo indicates a mean annual rainfall of approximately 2400 mm with above 100 mm rainfall recorded each month throughout the year (1960 to 2015; Figure A2.8). Mean daily temperatures are typically between 24 and 26°C throughout the year, with mean minimum and maximum temperatures within the 20 to 30°C range.



a.



b.

Figure A2.8. Mean annual rainfall (a.) and mean monthly maximum and minimum temperatures (b.) recorded at the Pekoa weather station, Espiritu Santo, Vanuatu. (BOM 2020).

Data in each of the three village sites was incomplete with missing data largely due to school vacations, particularly in December and January each year. Data for Sara was omitted in March-2018, where a monthly rainfall in excess of 2000 mm was recorded. Tropical Cyclone Hola was active to the south of Santo between 06- and 11-March-2018 and reports of between 60 and 210 mm rainfall were recorded in a 24-hour period, however it is unlikely this amount of rain was sustained for the seven days as recorded at Sara (200 mm/day).

In hindsight, automated weather stations with loggers located in each site would have provided more accurate rainfall data, albeit resulting in less engagement of staff and students in the rainfall collection process. Regardless of the issues with data collection, it is evident that all three villages received in excess of 2000 mm rainfall averaged across 2018 and 2019, the data would suggest that Sara village had the highest annual rainfall of the three village sites, whilst Port Olry had the lowest annual rainfall (Figure A2.9). Localised climatic data is non-existent in Vanuatu and is important to provide local evidence of any changes in climatic conditions and to assist with cattle management and marketing decisions. For example, rainfall data could be used to make decisions on weed control, pasture growth, water availability in pastures, when to commence destocking programs (and hence marketing decisions), and when to initiate pasture improvement programs.

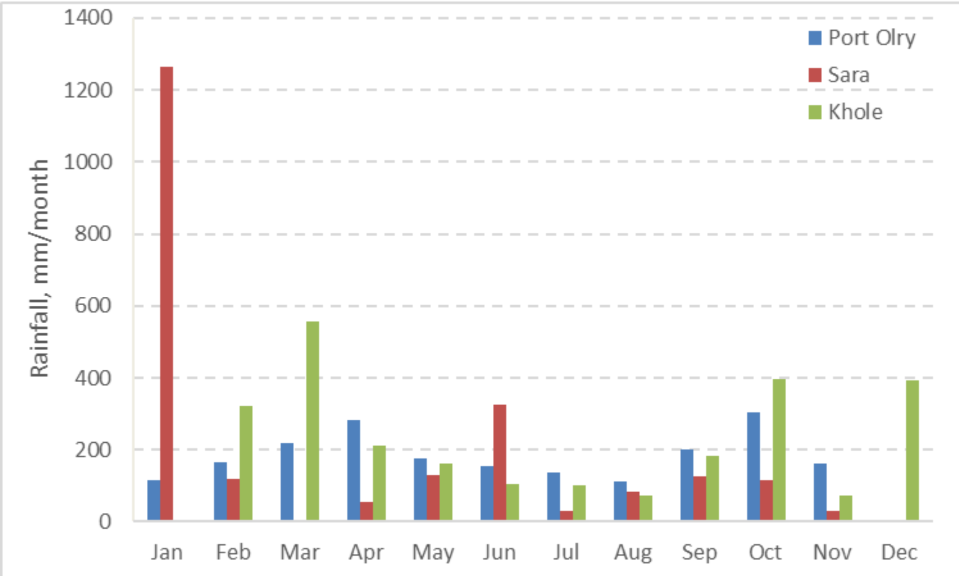


Figure A2.9. Manual rainfall data collected at primary schools located in Sara, Khole, and Port Olry villages in East Santo Area Council. Data is mean of 2018 and 2019 years.

Soils

Soil samples were collected from 11 sites broadly classified as east inland (five), east coastal (five) and south (one). All soils were brown clay (east inland and south) to brown sand (east coastal), and were neutral to slightly acidic pH (Table A2.2). All parameters were within the normal range for fertile soils. Whilst the soils would not be considered P deficient for animal growth, a yield response to P fertiliser may be evident on improved pastures. The results are generally in accordance with earlier descriptions across broader areas of Vanuatu (MacFarlane and Shelton, 1986; Quantin, 1982).

Table A2.2. Profile of topsoil (0 to 15 cm) collected from sites east inland (five), east coastal (five) and south (one) Santo, Vanuatu.

Parameter	East inland	East coastal	South
Soil colour	Brown	Brown	Brown
Soil texture	Clay	Sand	Clay
pH (1:5 Water)	6.5	6.0	6.0
pH (1:5 CaCl2)	6.1	5.5	5.6
Electrical Conductivity, dS/m	0.2	0.2	0.2
EC Saturation Index, dS/m	2.1	1.1	1.7
Chloride, mg/kg	32.4	41.0	28.8
Organic Carbon, %	3.9	3.4	3.3
Nitrate Nitrogen, mg/kg	0.8	.	1.0
Ammonium Nitrogen, mg/kg	96	80	104
Phosphorus - Colwell, mg/kg	26.0	19.0	18.6
Phosphorus - BSES, mg/kg	30.0	14.6	16.9
Phosphorus Buffer Index - Colwell	820	963	919
Sulphate sulphur (MCP), mg/kg	71.8	73.7	90.9
Cation Exchange Capacity - incl. Al (Amm. Acet.), cmol(+)/kg	18.7	14.3	14.0
Calcium (Amm. Acet.), cmol(+)/kg	15.7	10.9	10.7
Magnesium (Amm. Acet.), cmol(+)/kg	2.0	2.4	2.3
Sodium (Amm. Acet.), cmol(+)/kg	0.3	0.2	0.2
Potassium (Amm. Acet.), cmol(+)/kg	0.6	0.9	0.9
Available Potassium (Amm. Acet.), mg/kg	255	367	363
Calcium/Magnesium Ratio (Amm. Acet.)	11.0	5.0	4.7
Aluminium (KCl), cmol(+)/kg	.	0.1	.
Aluminium (KCl), mg/kg	.	9.3	.
Aluminium saturation, %	.	0.0	.
Calcium of cations, %	95	0	72
Magnesium of cations, %	4.0	0.0	19.0
Sodium of cations, %	1.9	1.4	1.4
Potassium of cations, %	0.7	0.0	6.6
Calcium/Magnesium ratio,	24.0	0.0	3.9
Aluminium (KCl) % of Cations, %	.	1.1	.
Zinc (DPTA), mg/kg	3.1	2.4	3.3
Copper (DPTA), mg/kg	14.2	11.3	16.9
Iron (DPTA), mg/kg	34.1	35.0	30.9
Manganese (DPTA), mg/kg	161	150	145
Boron (Hot CaCl2), mg/kg	0.7	0.6	0.7

Size of farms and stocking rates

The farms were geographically dispersed across the East Santo Area Council (Figure A2.10.) and ranged in size from 1 to 80 ha, with copra farms (13 ha; n=28) smaller than bush farms (42 ha; n=21). The majority of copra farms were a combination of copra and bush, with the small areas of bush on each farm potentially providing an opportunity for strategic pasture improvement for weaners within these mixed herd systems. The larger bush farm areas provide potential to develop significant areas of land with improved pastures to increase productivity, however such a program would require detailed planning and investment (fencing, labour).

Figure A2.10. Location and maps of individual farms involved in project activities in East Santo Area Council. (Source: GoogleEarth).

Calculations of stocking rates across the classification systems reflected the visual assessment of land condition and were 2.5 (weed ingress under copra), 4.0 (overgrazing under copra), 1.4 (well managed buffalo grass under copra), 0.9 (semi-improved bush), and 1.6 (improved bush) AU/ha. The VPIP recommended 2 AU/ha on open Buffalo grass-legume pastures, and 1 AU/ha on buffalo grass under coconut plantations (at ~50% light inception under 20 to 30-year-old coconut trees). It is likely that the high stocking of pastures under coconuts will result in low productivity, however it is also appreciated that high stocking density will allow for easier harvesting of coconuts. Rotational grazing would allow for coconuts to be harvested after grazing plus provide an opportunity for pastures to recover before the next grazing event.

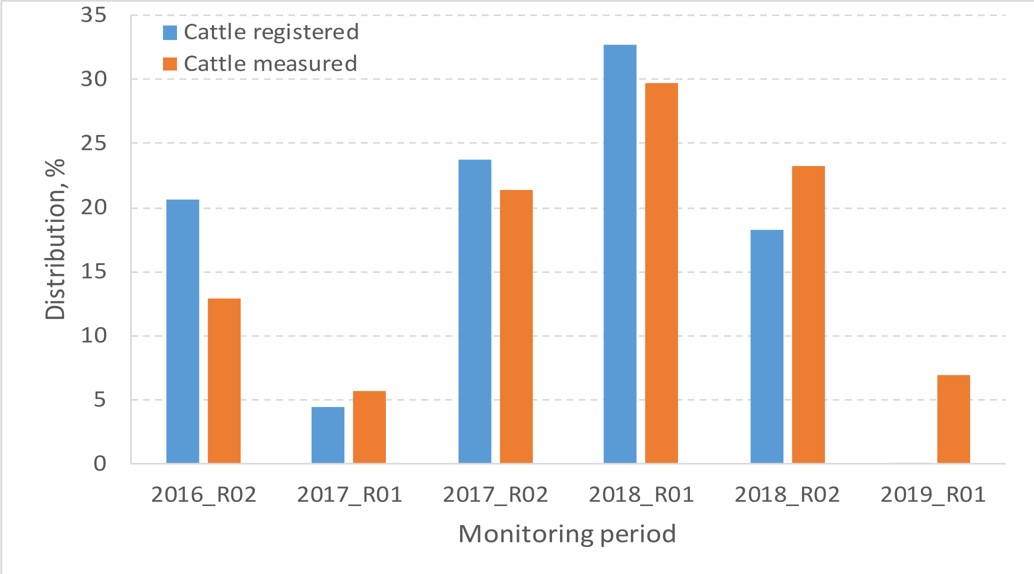
Cattle monitoring

Forty-nine households participated in regular cattle monitoring at various stages of the project across the five cattle production system classifications (Table A2.3). A total of 1244 cattle were registered across the 2.5 years, from which a total of 1944 animal measurements were recorded. This equates to approximately 1.5 measurements per registered animal, however 61% of all registered animals only presenting for a single measurement at registration. Numbers enrolled and numbers monitored peaked during the 2017_R02 and 2018_R01 rounds and declined thereafter. The peak in monitoring and enrolments may have been related to a spike in farmer interest or (from a logistics perspective) the organisational assistance of a volunteer working with the team from July-2017 to June-2018. The decline in numbers at 2018_R2 was due to unfavourable weather conditions and staff constraints at the time, whilst no new animals were enrolled at the final monitoring event of 2019_R1.

Table A2.3. Description of households involved in cattle monitoring in East Santo Area Council.

Category	Copra weeds	Copra overgraze	Copra well	Unimproved bush	Improved bush
Number of households	7	14	7	16	5
Farm size, ha	15	12	13	44	39
Number of cattle registered	112	401	167	396	168

The low numbers of animals returning for repeat measures was largely a result of incomplete musters, rather than disposals (sales, gifts, obligations, exchanges) or mortalities. At the 2019_R1, the project introduced a rewards scheme for farmers to encourage a more complete muster resulting in over 50% of farmers presenting more than 75% of the animals that had been previously enrolled in the project. The incentives offered were small tools that could be of assistance with farm improvement (wire, pliers, fencing strainers). This type of incentive should be considered as a reward for farmers time when data collection puts an increased burden on their time. The highest number of cattle registered in the project were managed on overgrazed pastures under copra plantations, whilst the smallest number of cattle were managed on heavily weeded pastures under copra plantations (Figure A2.11 and Figure A2.12).



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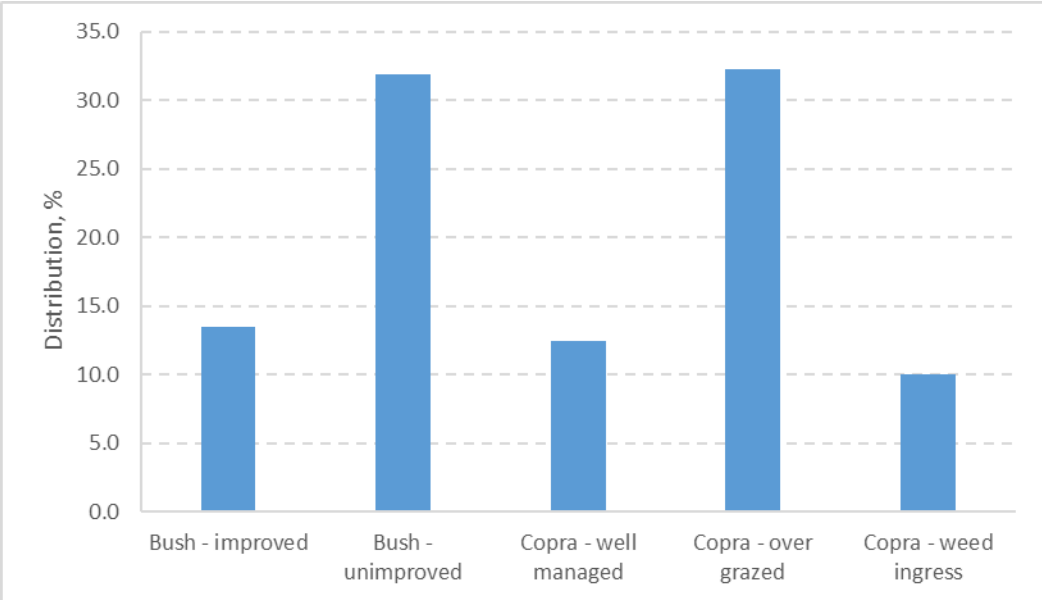

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Figure A2.11. Distribution of animals enrolled and monitored across the project (a.) and across the cattle farming classifications used in the project (b.).

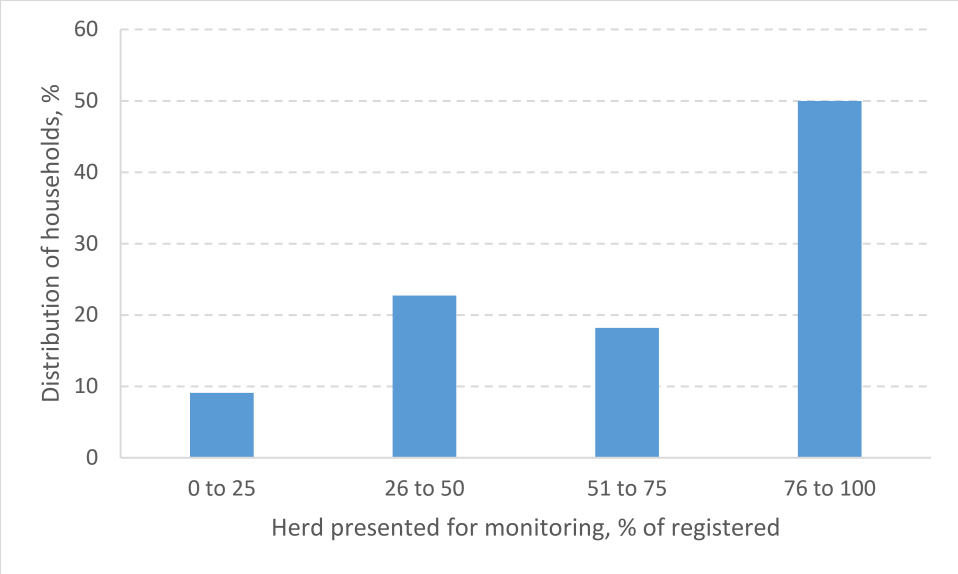


Figure A2.12. Effect of small incentive scheme on return of cattle to monitoring in 2019_R1.

Cattle management practices

Information on herd level cattle management practices were collected at each monitoring visit on each farm. Rotational grazing was reported on 80% of all herds monitored and was higher than expected. There was typically a small number of paddocks on each farm (two) with cattle rotated at fixed times rather than based on pasture availability or quality. Only 10% of farms reported having drinking water available for cattle at the time of monitoring, which is comparable to other surveys conducted by the current project and NZ MFAT (2017). Animal health treatments were not applied to cattle over the monitoring period. Approximately 10% of all cattle monitored were tethered, with the majority of these steers and heifers during and after weaning with an average liveweight of 265 kg. Approximately 25% of all cattle monitored were either castrated or dehorned by the project team and the ability to do this safely was a major incentive for farmers to participate in cattle monitoring.

Herd profile

Herd profiles were determined using two methods. Initially household surveys indicated a total herd profile across 48 households (Figure A2.13). The proportion of cows within the herd appeared high (60% of cows, steers and heifers) and, considering the low proportion of calves (i.e. low reproduction rates) and low number of replacement heifers on hand, this indicates farms are carrying a large number of unproductive breeders which would contribute to the high stocking rates identified earlier. The overall proportion of bulls was high (3.4%) but expected given the small herd sizes (i.e. at least one bull is required regardless of the number of breeders), however it was noted that 20% of farms recorded no bulls, with all of these having herds under coconuts. As all farms reported some calves it was understood that neighbours' bulls may have been used on some occasions. Data collected at regular monitoring visits using a combination of animal count (cattle present in yards) and farmer supplied data (cattle not present yards) resulted in a similar herd profile.

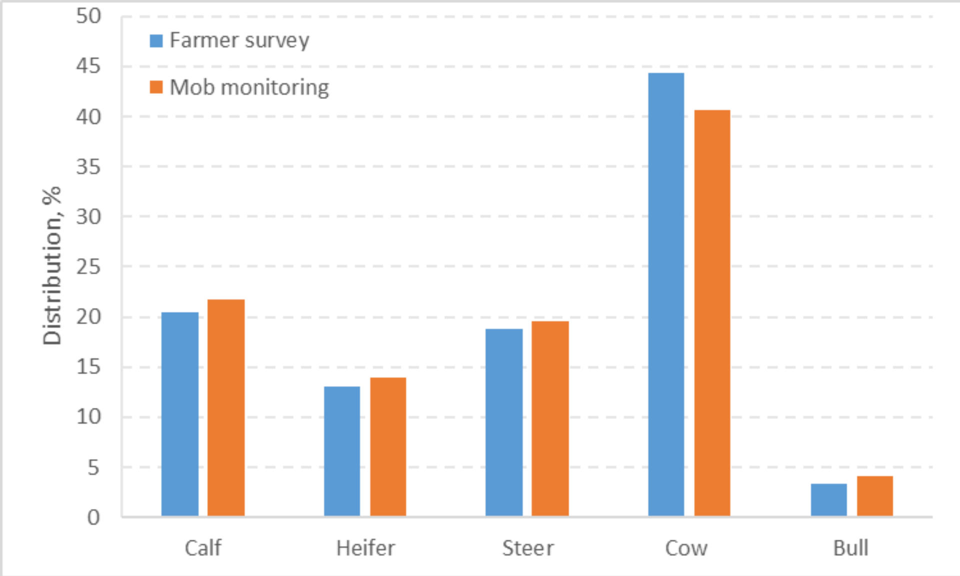


Figure A2.13. Profile of cattle herds in East Santo Area Council from farmer surveys and at regular monitoring visits.

Productivity

Calving distribution and calving percentages

Month of calving data was recorded for cattle born in 2016, 2017, and 2018 (n=513). Calving occurred throughout the year but with a peak in the late wet- and early dry-season (43% in June, July and August; Figure A2.14). This would correspond to a conception period of October to December probably in response to the onset of the wet season. Whilst calving during the peak wet season may be considered undesirable due to high humidity and increased risk of internal parasites, calving in the dry season may also be problematic, particularly in drier years, if drinking water is unavailable resulting in suppressed milk production and an increased risk of calf dehydration and incidence of calf mortality.

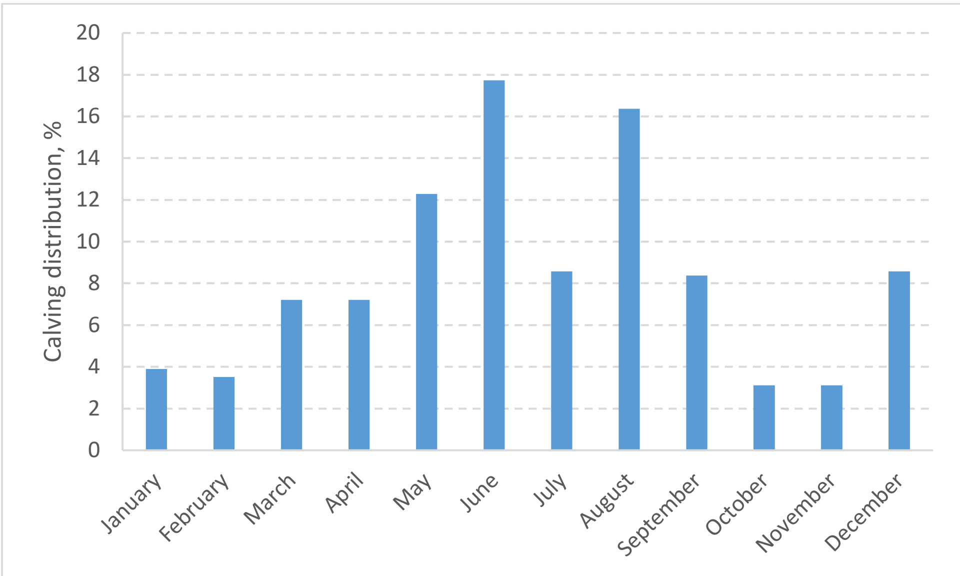


Figure A2.14. Distribution of calving in cattle herds in East Santo.

Calving rates were determined by several methods. Initially from farmer supplied survey data a calving rate of 46% was determined (number of calves/number of cows in a single herd). Herd profile counts at regular monitoring visits, a combination of physical counts of animals in yards, and farmer supplied information on the number of animals not present in yards, indicated a calving rate of 53%. Whilst the regular monitoring data of cows present in the yards suggested that the number of cows lactating across all herds and monitoring events was 42.5%; this is likely to be an under-estimate if it is assumed that a higher proportion of cows with calves at foot were not mustered to the yards at monitoring. These data align closely with the NZ MFAT survey data (2017) which reported a calving rate of 40% for smallholder cattle farmers with herds of less than 50 cattle. Regardless of the exact value a calving percentage of below 50% is low by any standard. These low calving rates will translate to low weaning rates, which are key drivers of profitability in cow-calf production systems. Addressing these low reproduction rates is likely to significantly increase herd profitability. It is not unreasonable to suggest that modest increases in the calving rate from ~45 to 65% are possible through improved herd management (weaning, adjusting stocking rates by culling unproductive females and ensuring access to sound fertile bulls).

Analysis of the calving data disaggregated by cattle production system classification should be viewed with caution due to the small numbers of households and cattle present in some of these systems. Only small numbers of cattle were available for analysis, particularly in the improved bush systems which are typically used for growing out steers rather than breeding, so data from these systems were combined. Nevertheless, the data indicates calving rates of approximately 30% for cattle under copra plantations and 60% for those herds managed under bush respectively. There was little difference in calving rates between the different cattle systems under copra (28 to 32%). Data for farms with weed ingress were omitted due to data anomalies where more calves than cows were reported in two herds inflating the overall calving rate to almost 100% which is unlikely.

Cow body condition score and liveweight

The average liveweight and body condition score of all cows across all monitoring events was 360 kg and 2.8 respectively, with forty percent of all cows recorded as lactating across all monitoring events (Table A2.4). Non-lactating cows (365 kg) were marginally heavier than lactating cows (352 kg) and this was reflected in marginally higher body condition scores in non-lactating cows (2.9 v 2.7). Cows were slightly heavier (370 kg) in the first-round muster (early dry season) than at the second-round muster (late dry season) (353 kg). Across all measurements cow liveweight ranged from 172 to 544 kg with a 1 to 5 body condition score.

Table A2.4. Body condition score and liveweight of lactating and non-lactating cows managed in bush grazing systems or under copra with well managed Buffalo grass, overgrazed Buffalo grass or with high weed ingress in East Santo Area Council.

Production system	**Early dry season**		**Late dry season**	
Body condition score	**Lactating**	**Non-lactating**	**Lactating**	**Non-lactating**
Bush	2.75 (34)	3.10 (29)	2.80 (81)	2.80 (71)
Copra – well	2.70 (10)	3.40 (55)	3.05 (23)	2.95 (50)
Copra – overgrazed	2.65 (38)	2.63 (83)	2.40 (67)	2.90 (94)
Copra – weeds	2.66 (9)	2.92 (9)	2.90 (14)	2.80 (19)
Liveweight, kg	**Early dry season**		**Late dry season**	
Production system	Lactating	Non-lactating	Lactating	Non-lactating
Bush	370	351	349	341
Copra – well	387	432	393	408
Copra – overgrazed	357	344	320	341
Copra – weeds	344	359	374	382
Value in parenthesis is number of animal records per measurement				

Body condition scores ranged from 2.4 to 3.4 and were relatively consistent throughout the year and between grazing systems. Cows tended to be of higher liveweight and body condition score at the early dry season muster round, regardless of lactation status or grazing system, with the exception of cows grazing under copra with high weed ingress, which appeared in better condition at the end of the dry season. Cows grazed under copra on well managed buffalo grass were heavier and in better body condition than cows grazed under copra at higher stocking rates. Interestingly, cow grazing areas with higher weed ingress were not as light in liveweight or body condition as those where over-grazed buffalo grass and carpet grass existed, but weeds had not established to the same extent. This would suggest that these non-grass species were forming a significant part of the diet and were of higher nutritional value than otherwise expected. Despite lower stocking rates and more available biomass, cows managed under bush based systems were no heavier or in a higher body condition than those under copra on well managed buffalo grass pastures. This demonstrates that it is possible to maintain cows in good condition under copra with appropriate stocking rates.

In general, the body condition score was marginally lower than a target score of 3 at calving, but rarely below 2.5; a lower calving rate would be expected for cows in a body condition score below 3 at calving. The overall liveweight of a non-lactating cow of 365 kg was significantly lower than that used as a reference for 1 animal unit (450 kg). The reason for the lower mature cow weight is unknown and could be a function of undernutrition at critical stages of the growth path or reflect the genetic potential of smallholder bred cattle. Either way, smaller mature sizes may have implications for stocking rate recommendations. This was exactly the reason that the original Activity 2.3 was proposed to determine if there are differences in the genetic potential for growth of smallholder cattle when managed under best practice.

Even at a body condition score of 3 at calving this would equate to ~60% of all cows confirmed pregnant at weaning 6 months later. This would decline to ~40% pregnancy rate for cows at a body condition score of 2.5. There can be significant gains in reproduction rates by increasing the body condition score of cows to above 3 at calving. However, to recover one body condition score, a mature cow will need to gain approximately 50 kg liveweight and under these conditions this would take approximately 6 months for a non-lactating cow to move from a score of 2.5 to 3. Weaning to remove lactational stress, destocking by culling unproductive females, rotational grazing, and controlled mating periods will all assist to address this issue of recovery or maintenance of liveweight and body condition score of cows after weaning.

Liveweight gain

Overall growth rates were higher for steers and calves over the dry season and for cows and heifers over the wet season (Table A2.5). Anecdotal evidence has indicated this is common in the wet tropics where the high water content of pastures, coupled with humid and hot climatic conditions result in decreased intake. Seasonal and annual growth rates were low across all systems with flow on effects on the time taken for cows to recover body condition, the time required for heifers to reach a critical mating weight (assumed to be 65% of mature size; 3.5 years) and the time taken for steers to reach slaughter weights (~4.5 years) that would attract price premiums on existing price grids.

Table A2.5. Liveweight gain of calves, heifers, steers, and cows in the wet and dry season averaged across all production systems in East Santo Area Council.

Class	Wet season, kg/day	Dry season, kg/day	Annual liveweight production, kg
Calves	0.34 (38)	0.41 (30)	136
Heifers	0.39 (22)	0.16 (29)	106
Steers	0.27 (101)	0.33 (58)	110
Cows	0.07 (101)	-0.06 (86)	5

Values in parenthesis are the number of animals recorded
Annual liveweight production calculation was extrapolated using a 210-day wet season and 155-day dry season

This study intended to break this data down further by grazing system, however repeat measures for individual animals were limited. Some examples of longitudinal data collected on four farms with three to five steers is presented below (Figure A2.15). Whilst low growth rates are common across all herds, these appear lowest for cattle under copra when overgrazing has occurred, and when heavier more mature steers are maintained under copra plantations. In both scenarios there would be insufficient ME available to sustain growth rates. For these heavier steers, there are limited financial gains in retaining them, particularly as they would already attract the highest price on the existing price grids. These heavier steers are simply consuming pasture that could be utilised by lighter animals, but not gaining any liveweight.

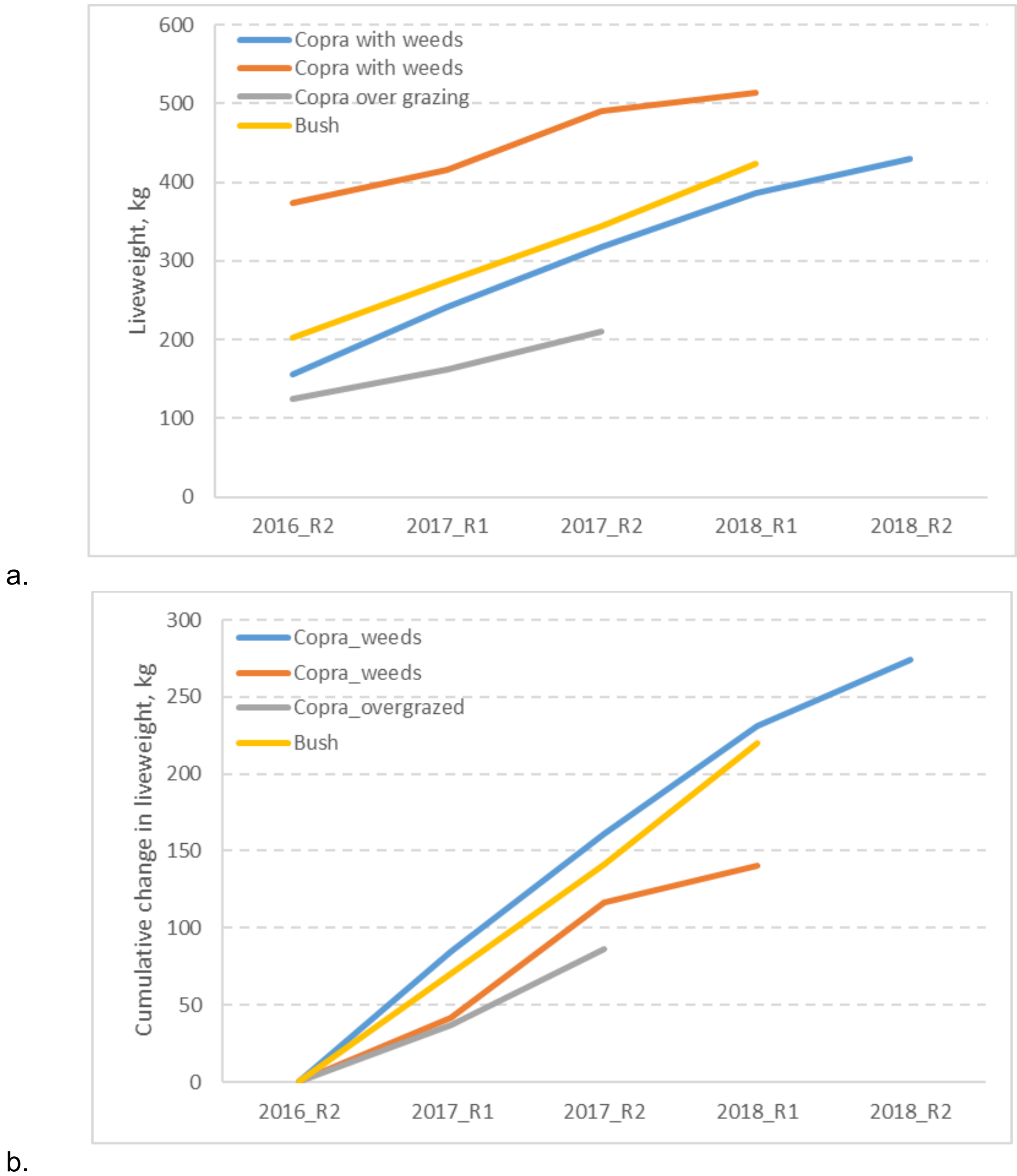


Figure A2.15. Liveweight (a.) and cumulative change in liveweight (b.) of steers under different grazing systems in East Santo Area Council. Each line represents the mean liveweight of three to five steers on a single farm.

Mortalities and disposals

Only one-third of farmers reported a mortality in their cattle herd in the 12 months prior to their involvement in the project, with an average of two to three mortalities reported. If an average herd size of 20 cattle is assumed this would be a mortality rate of approximately 10%. Mortalities were less frequent in the wet season but generally occurred throughout the year (Figure A2.16). Whether this difference is due to seasonal conditions or lack of observation in the wet season when cattle may be more difficult to access is unknown. Generally, the causes of mortalities were unknown.

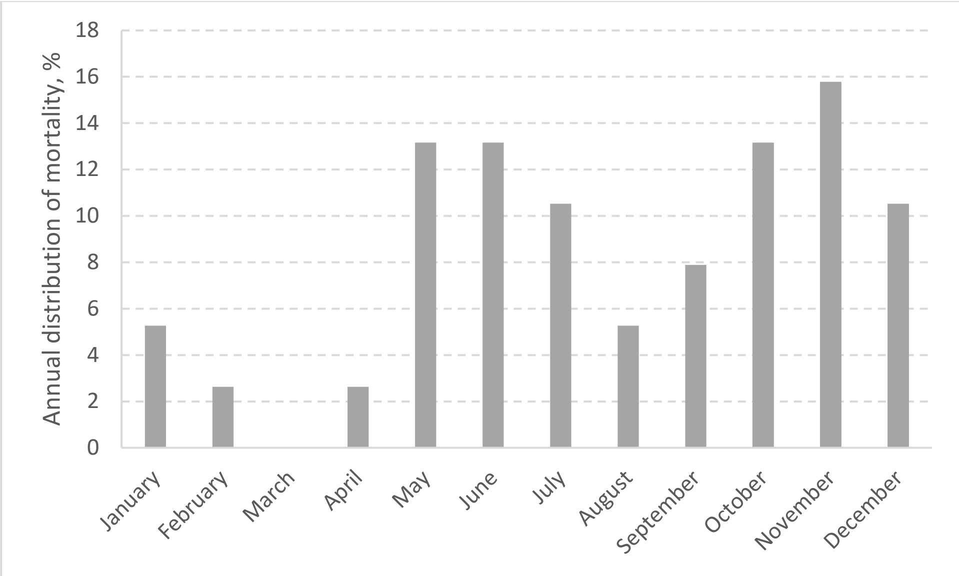


Figure A2.16. Annual distribution of cattle mortalities. Data from farmer surveys.

Internal parasites of cattle on selected farms in East Santo Area Council

Given the high stocking density and wet and humid conditions for much of the year it was hypothesised that internal parasites may have an effect on the productivity of smallholder cattle herds. Enumeration and identification of eggs in faeces of cattle mobs managed under different systems revealed the presence of strongyl eggs and eimeria oocysts in cattle across all systems. However, burdens detected were likely to be lower than those required to reduce productivity across the measurement period (Figure A2.17). Spikes in egg loads were detected in some systems (semi-cleared bush, weeds under copra) for one or two months but quickly returned to low levels. Eimeria were undetected, or detected at low levels only, across most systems most months of the year. This is typical of most cattle herds and is unlikely to have a negative impact on productivity. It should be noted that samples were collected from mob level faecal deposits at random and most likely represent burdens in adult cattle which make up the highest proportion in these herds, and as such are less sensitive to internal parasites in younger cattle which may shed more eggs. Nevertheless, the results indicate that internal parasites do exist in cattle herds in East Santo and whilst levels were low in the measurement period infection may increase under favourable conditions. Ongoing monitoring in susceptible herds may be warranted when conditions are favourable (wet conditions, overgrazed pastures). Training farmers on prevention options to avoid infection is likely to be more beneficial than providing treatment options after infections are detected. Dr Anne Beasley (UQ) provided training for local staff at the Dept. Livestock and Biosecurity Vanuatu on the collection and processing of samples, and the enumeration and identification of eggs in faeces. This capacity will ensure that local expertise is available to assess potential internal parasite outbreaks in future.

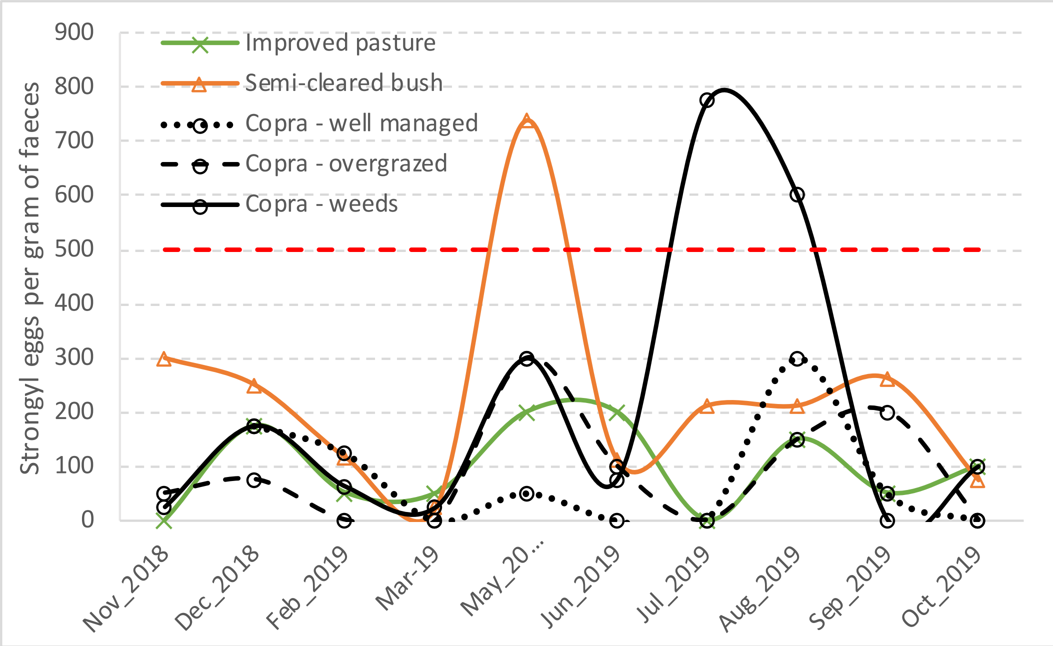


Figure A2.17. Mean count of strongyl eggs present in the faeces of cattle herds in East Santo Area Council, Vanuatu. Red dashed line indicates threshold below which negative effects on productivity are unlikely to be observed.

Quality of diet consumed by cattle on selected farms in East Santo Area Council

Near-infrared reflectance spectroscopy (NIRS) of faecal samples collected from cattle can be used to predict the crude protein (CP) content, digestibility (DMD), and the non-grass proportion of the consumed diet. Calibration equations generated for young, growing cattle, fed a range of tropical forages in northern Australia, were used to estimate the CP content, DMD, and the proportion of non-grass in the diet consumed by grazing cattle in East Santo Area Council.

The estimated CP content of the diet consumed by cattle across all farms generally fell within the 7.6 to 16.3% range, tending to be lower in the late dry season months of August and September each year (Figure A2.18). The diet DMD reflected that of CP content across all farms and generally ranged from 44 to 68%. The higher than expected predictions of diet quality consumed by cattle under unimproved conditions (overgrazing and weeds under copra plantations) are attributed to a high proportion of non-grass in the diet, which was relatively constant throughout the year (Figure A2.19). Local leguminous plants and other shrubs and trees are available across much of Vanuatu in conjunction with small amounts of leaf regrowth on native grasses and generally provide small quantities of green, high protein material in the dry season. The prediction of the proportion of non-grass in the diet was variable (0 to 65%, mean 24%) across the farms but appeared highest on farms where cattle grazed under copra plantations with heavy weed burdens. While the quality of the diet consumed by the cattle on the farms monitored may be high, the quantity may have been limiting production, particularly where cattle grazed under copra at high stocking rates, where pasture biomass was low, or where weed burdens were high. In these circumstances, cattle are likely to have been consuming small amounts of a diet with a relatively high CP content (i.e. young regrowth or leguminous weeds) but limited amounts of ME.

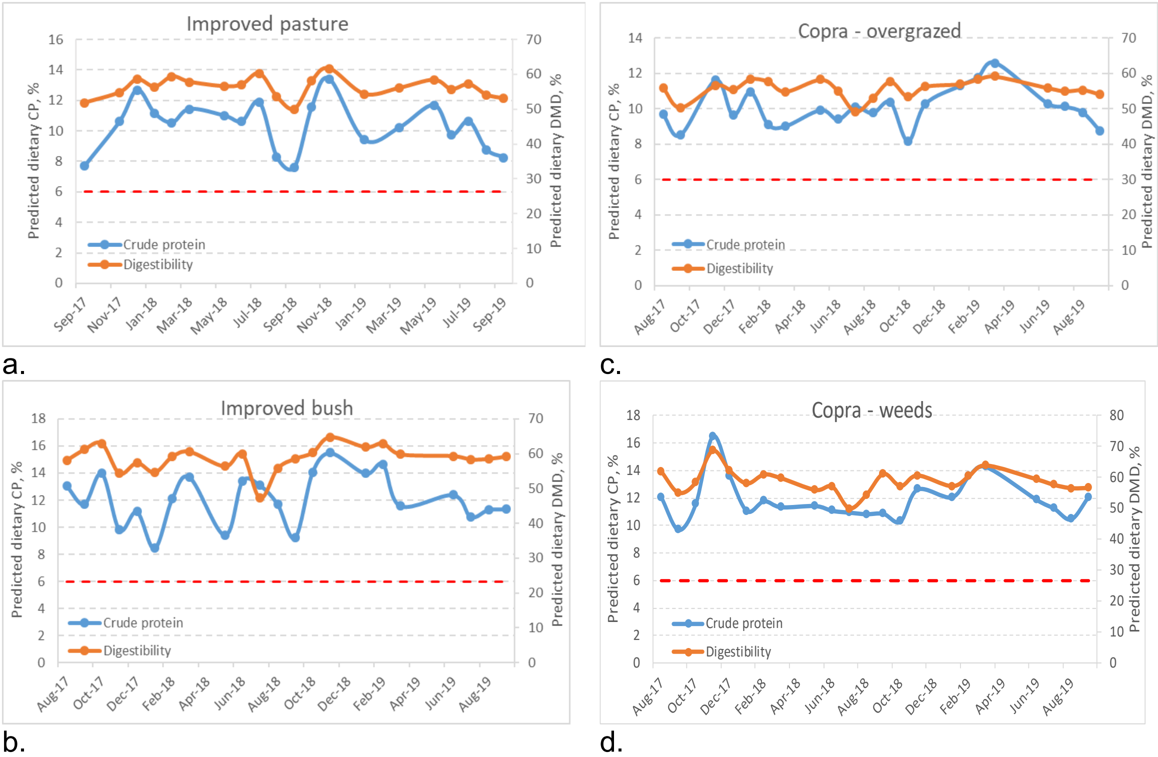


Figure A2.18. Monthly variation in the estimated crude protein (CP) and dry matter digestibility (DMD) content of the diet consumed by cattle grazing improved pastures (a.), cleared bush pastures (b.), over-grazed (c.), and heavily weeded (d.) pastures under copra plantations across East Santo Area Council. Red dash line indicates minimum dietary crude protein requirements.

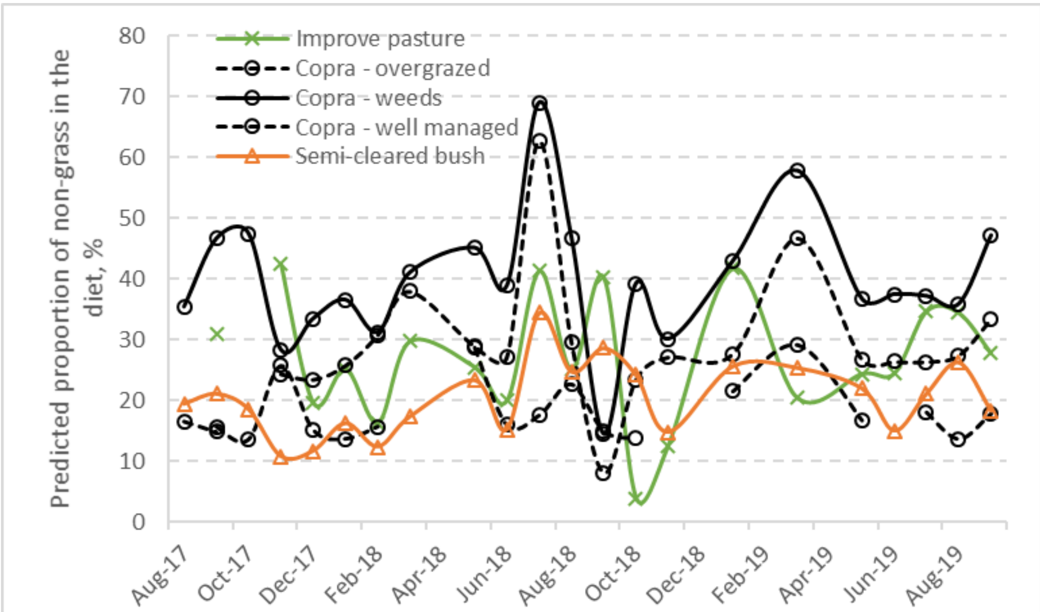


Figure A2.19. Monthly variation in the estimated proportion of non-grass in the diet consumed by cattle grazing within different conditions across East Santo Area Council. Data are mean for each grazing condition.

Conclusions and recommendations

There were challenges in the collection of cattle production data in the field across smallholder farms in Vanuatu. These included the extensive cattle management systems, lack of appropriate infrastructure, farmer time commitments, and farmers not yet fully trained in the significance of the data that was generated and how it could be used in decision making. A small incentive scheme introduced at the end of the project increased the number of cattle presented for monitoring within a herd. As a result, the data set collected over the two-half years is limited and as such should be viewed with some caution. The collected data, in conjunction with other survey data and farm appraisals, does provide baseline data on cattle productivity across a number of production systems from which recommendations for future management options can be identified, modelled (biological and economic), and tested under field conditions.

The productivity of smallholder cattle production systems in East Santo Area Council is comparable to that of low-input smallholder systems in other countries, with low liveweight gain (0.1 to 0.4 kg/day) and low calving rates (less than 50%) observed. The low productivity is likely to be a result of inadequate total nutrient supply rather than diet quality *per se*, as indicated by F.NIRS predictions of high quality diet consumed by cattle throughout the year under all grazing systems. Whilst faecal egg counts indicated the presence of strongyles in cattle herds, burdens were expected to be low and unlikely to have a negative impact on productivity but could potentially increase under favourable conditions. The low reproduction rates are likely to be a function of inadequate nutrition in bush based systems and access to a fertile bull in cow-calf systems managed under copra plantations. However, the soundness (and age) of bulls, reproductive diseases, and mineral deficiencies all warrant further investigation. Whilst pasture improvement programs, coupled with appropriate grazing management, will undoubtedly increase productivity (as evidenced in the Vanuatu Pasture Improvement Program and results from on-station monitoring in the current project). This would be a major shift in direction for most smallholder farmers and would require a significant investment of resources, exposing farmers to significant risks unless implemented in a structured manner and with appropriate mentoring. In addition, the culling of unproductive female cattle would reduce stocking rates, increase available ME, and reduce weed ingress, and subsequently increase calving rates and weaning liveweight and overall productivity. To achieve these increases in productivity would require increased capacity of farmers, infrastructure improvements to allow for segregation and the rotation of different cattle classes, and access to sound fertile bulls.

Activity 2.2. Implement and monitor on-farm interventions to improve production

Prepared by: Simon Quigley

Introduction

On-station research visits and survey data collected in the early stages of the project identified potential areas of work that could be implemented by smallholder cattle farmers in East Santo to overcome limitations to cattle production. The aim was to pilot test some interventions to assess the potential impacts on cattle productivity and household livelihoods and, more importantly, assess what implementation models facilitated the engagement of farmers in on-farm research activities. Through in-depth interviews, including the storian sessions in the livelihood's analysis, farm visits, and quantitative surveys it was demonstrated that most farmers identified a lack of drinking water as a major constraint to current on-farm productivity, and future farm improvements. This was identified as one intervention that could be tested with smallholder cattle farmers.

On-station research conducted at VARTC, demonstrated that a range of alternative grass and legume lines were well adapted to the wet tropical environment of Vanuatu. Several farmer visits to on-station forage evaluation trials were conducted in 2017. During these visits, farmers asked a range of additional research questions and expressed an interest in evaluating these forages and then propagating these on their own farms. The on-farm evaluation of forages by farmers was considered a second intervention to be tested with smallholder cattle farmers. The questions that farmers asked during these visits included:

1. What forages will grow best on my (smallholder) farm(s)?
2. Are these forages easy to grow and maintain on my (smallholder) farm(s)?
3. How long will these forages persist for?
4. Will cattle eat these forages?
5. Will cattle liveweight gain be increased if they consume these forages?
6. What stocking rate is appropriate for these forages?
7. What legumes and grass combinations are best on my (smallholder) farm(s)?
8. How easy and how much vegetative material will be required to scale-out to 1 ha of land (by transplant)?
9. How can weeds be controlled in improved forages pre- and post-emergence?

Materials and methods

Drinking water supply to smallholder cattle

Through interviews, surveys, farm visits, and secondary data sources a lack of drinking water was identified as a priority constraint to cattle farming by both farmers and the project team. During catchment meetings this issue was discussed with farmers to identify potential solutions and models to test these solutions. It was determined that farmers were unlikely to share infrastructure unless between family members and that single household units should be engaged in the activity rather than groups of households. In addition, it was expected that the ongoing maintenance and repairs to pumps and pipes was likely to be an issue in many areas due to limited capacity and funds. Laying pipes across neighbouring land was not considered an option due to jealousy that may be created and issues with access to land. Therefore, it was decided that water supply must be generated and conserved on an individual farm using models that did not require ongoing maintenance. Ground tanks are largely non-existent in Vanuatu due to the porous nature of many of the soils, plus the equipment required for construction. Instead, the project focussed on two potential models to supply drinking water to cattle:

1. Shallow wells in coastal fringes, and
2. Rainwater tanks attached to existing infrastructure (e.g. copra driers)

It was decided that a co-investment model would be proposed to farmers where the project would match funding from interested farmers to establish infrastructure, with the project facilitating the supply of materials and labour for the construction. It was decided that a case study approach for monitoring would be appropriate for this intervention. Only one farmer was interested in investing in such a model.

On-farm forage evaluations

Initially it was proposed that only a small number of households would participate in the on-farm forage evaluation trials (n=10) however once sites were established interest amongst farmers was increased and additional farmers were supplied with wire and seed to establish their own sites. A total of 20 households or individuals were provided with wire and grass and legume seed across East Santo. An additional seven households were provided with seed to independently establish their own sites after requests were made to the project team. An additional two sites established leucaena (*Leucaena leucocephala*) nurseries and transplanted leucaena seedlings on fenced grazing land in Fanafo Area Council (Figure A2.20).

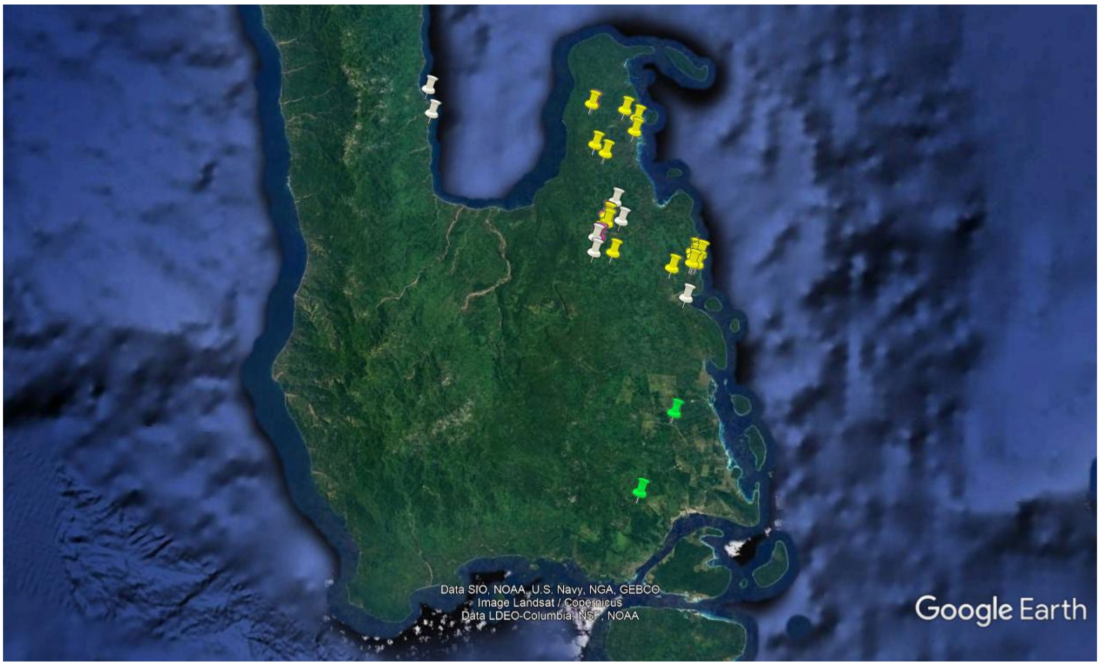


Figure A2.20. Distribution of water catchment and legume bank sites (pink icon), on-farm forage sites (yellow and white icons) and leucaena sites (green icons) in East Santo Area Council.

From the on-station forage evaluation sites the following grass lines were selected for on-farm evaluation. These were selected through a combination of farmer interest and researcher experience (likelihood of establishment, ease of management, ease of propagation or seed collection, various roles in grazing systems, and familiarity by farmers). The selected grass lines were Basilisk (*Brachiaria decumbens*), Mombasa (*Panicum maximum*), Mulato2 (*Brachiaria* hybrid), Mekong (*Brachiaria brizantha*), and Sabi (*Urochloa mosambicensis*). The selected legumes were Rongai (*Lablab purpureus*), Milgarra (*Clitoria ternatea*), Temprano (*Stylosanthes guinanesis*), and Tinaroo (*Neonotonia wightii*).

Farmers were asked to identify a small area (20 x 20 m) where they would like to establish the forage plot. This area was recommended as it was estimated to provide sufficient vegetative material to develop 1 ha of improved forage, and as such could be used as a nursery in the future. Whilst it was recommended this be established near to the house for ease of monitoring and management (i.e. weeding) most farmers established their plots near grazing lands for ease of propagation later. After farmers had established posts around their proposed plot areas, the project team supplied one roll of barb wire, fencing staples, and applied herbicide across the plot to reduce weed loads. Farmers in each village site were invited to a demonstration day, where the project team and farmers cleared the plot area and planted seeds. Farmers were then provided with small packets of each of the seed lines to establish their own forage plots. Once established farmers were encouraged to graze the small plots with one or two weaners every 60 to 90 days with monitoring to occur throughout 2018 (in the wet and dry seasons, so that farmers could make longer-term decisions rather than based solely on establishment). At the end of this period, farmers were able to select their preferred species for propagation on their own land. Monitoring was undertaken using CommCare where photos of each plot and farmers preferences were to be collected, approximately every 60 to 90 days after each grazing.

Results and discussion

Water supply to smallholder cattle

Whilst farmers identified a lack of available of drinking water as a major constraint to cattle production systems and were interested in having water supplied to their farm, very few were interested in the infrastructure co-investment model proposed by the project. A single farming household in Port Olry requested to participate in this activity under the proposed co-investment model.

The household owns land at both Sara and Port Olry villages but reside mostly at Port Olry. Cattle are grazed on fenced customary land (18 ha) approximately 10 km from their home in Port Olry and they typically visit their farm and cattle once or twice each week. The current herd consists of 22 cattle, of which 15 are breeders whilst the farmers report a calving rate of 100%, the herd profile would suggest this is unlikely unless all progeny are sold at a very young age. The farmers believe the dry season is becoming increasingly variable due to climate change, with the driest part of the year now December, which is much later than in the past. As a result of their participation in the project the farmers divided their farm into five smaller paddocks, to allow for rotational grazing where cattle are rotated to a new paddock every week.

There was no drinking water available to cattle on this farm. In past dry seasons the farmers observed breeder mortality in the dry season (three or four cows in a particularly dry year and would equate to approximately 20% of a 15-breeder herd). The farmers had observed that the larger ‘Mission’ farm supplied water to their cattle and did not experience dry season mortalities. The farmers started to provide banana trunks as a source of water and then started transporting water from a stream near Port Olry to their farm each week in 44-gallon drums. They now leave these drums on the farm with sheet iron to catch and store water for the cattle but still need to transport water to the farm when cattle become weak. It costs the farmers 2000 vatu/load of water plus their own time and labour to fill the drums. After participating in project training on market access, they decided to sell five steers to generate cash to invest in the water supply system. They realise this is a long-term investment but expect benefits in terms of increased growth rates and higher calving rates, plus labour and funds previously allocated to water transport may now be directed to weed management on the farm. They also believe that the rotational grazing will reduce water requirements by the herd as pasture regrowth is ‘fresher’ and contains more moisture than the overgrazed short grasses or under-grazed rank grasses that previously existed on the farm.

As a demonstration site, the location (Figure A2.20) was not desirable due to accessibility challenges, but in the absence of other collaborating farmers it was deemed to be the best option available. The proposed model to supply water in this remote area was a cement tank attached to existing roofed infrastructure (i.e. a copra drier). The installed model actually did not link to the existing copra drier but involved the construction of a small shed which had a far smaller catchment area than the copra drier. The water requirements model developed by the project was used to estimate the size of catchment area and size of tank required to supply drinking water to this herd throughout the dry season (using rainfall data from the Pekoa meteorological station, grass water content data from VARTC, and water requirements from the Australian feeding standards for ruminants (NRDR, 2007). A 20,000 L cement tank was proposed to hold sufficient water for this herd over a 12 month period. The model is particularly sensitive to the size of catchment area and the dry matter content of the pasture consumed by cattle. Using data described above (rainfall and pasture dry matter content) it was modelled that an 11 x 11 m catchment would provide *ad libitum* drinking water for this herd throughout the year. A smaller catchment would likely require some restrictions to drinking water in the mid- dry season to ensure that water is available in the late-dry season.

Construction of the site was conducted through the dry season of 2019 and was completed in October-2019 (Figure A2.21). The tank was to fill through the wet season and associated infrastructure was established on site to supply water from the tank to a drinking trough through the dry season. The farmer proposed to integrate the water system into a new stockyard, with water to be used as an attractant to handle cattle for husbandry and marketing activities. The cost of materials, transport, and labour for the 20,000 L cement tank was ~470,000 vatu (AU$6000), with an additional 60,000 vatu required for the small catchment. Additional infrastructure (water trough, pipe, fencing, and stock yards) will incur additional costs. A 10,000 L poly tank costs approximately 600,000 vatu (excl. delivery and installation). At this stage it is not possible to model the economic returns of the investment, however any reduction in breeder and/or calf mortality is likely to have a large bearing on returns on investment over the >20 year expected life of the cement tank. Further follow-up interviews will be required with the farmer over several years to cover variable seasonal conditions. For example, benefits may not be apparent in normal seasonal conditions, however large benefits are likely to be apparent in an extreme dry year (e.g. 2015) where breeder mortality was reported with a long time required to rebuild herds.

Figure A2.21. Cement water tank and catchment established near Port Olry, East Santo Area Council.

The co-investment model would initially appear to be unattractive to smallholder cattle farmers, so it is assumed sole investment would also present a challenge. However, it is noted that the farmer who committed to this activity was an active participant in training and research activities, and perhaps had a different understanding of the potential benefits of supplying drinking water to cattle, which were largely based on their own experiences and observations. It is likely that with further training other farmers may appreciate the potential benefits and invest in water infrastructure in the future. There was, and still is, limited empirical evidence as to what the likely returns on this type of investment may be to farmers under local conditions. This initial pilot site and the lead farmer sharing experiences with other farmers may initiate broader interest in both the model installed and the investment models required. It is likely that farmers would adapt the initial model in alignment with their own resources and requirements, and as such cheaper models may be developed. It should also be noted that only one model was established in the project.

On-farm forage evaluations

The project conducted training activities with interested and available farmers in December-2017 (the start of the wet season) as this was the preferred time for sowing plots. Many farmers had still not fully prepared fencing of their plots at this time but it was expected that the establishment of demonstration sites in each village and the provision of seed would stimulate preparations (Figure A2.22). The majority of the plots were sown through February and March-2018, which was suitable given the generous wet seasons experienced in East Santo and would suggest this may be a favourable time for these activities with smallholder farmers. In general, all sites that were planted established well under the favourable growing conditions in Vanuatu (Figure A2.23). Some sites were not established due to ongoing time commitments of farmers and resulted in the re-ingress of weeds, rodents consuming seeds, and/or late plantings.

a.

b.

c.

Figure A2.22. Establishment of on-farm forage plots in Khole (a), Port Olry (b), and Sara (c) villages in East Santo Area Council.

Figure A2.23. Monitoring and grazing of on-farm forage plots.

Farmer preference was initially canvassed during visits to on-station evaluation plots at VARTC. The grasses preferred by farmers during the monitoring period were Basilisk and Mulato, with farmers indicating a preference due to fast growth and regrowth after grazing, a high amount of leaf relative to stem, and being preferentially grazed by cattle. The least preferred grasses were Sabi followed by Mombasa, with farmers stating these did not grow well or survive in some cases. All farmers indicated that they would plant grasses in the future and indicated that Basilisk (Signal grass) would be the preferred choice. Farmers also indicated that the legume Rongai grew quickly and established large amounts of biomass, followed by Milgarra because it was preferentially grazed by cattle. Temprano was the least preferred legume largely due to low acceptance by cattle, whilst Milgarra was also not preferred by some farmers as it did not regrow well after grazing. All farmers indicated that they would plant legumes in the future and indicated that Rongai (lablab), followed by Milgarra were preferred for future plantings. All farmers indicated the best aspects of this activity was that they could evaluate themselves what grass or legume to plant on their farm and had access to small amounts of planting materials. Approximately half the participating farmers indicated there was nothing negative about participating in the activity, the other farmers indicated it was laborious to maintain the plots through weeding and fence maintenance (to stop cattle entering the site, which could alternatively be viewed as a positive outcome).

Nine of the 20 sites were revisited, and farmers surveyed in November and December-2019, approximately 12 months after the end of the initial monitoring period. Other sites were visited but had been completely neglected and were no longer viable due to weed ingress. Of the viable plots visited one plot remained in excellent condition, one plot was in poor condition, and the rest were in a good condition. Mulato (7/9) was the preferred grass by farmers, whilst all farmers considered Sabi the least preferred grass due to slow growth and inability to out compete weeds. Tinaroo was the preferred legume (5/9) by farmers, which was different to feedback during the growing and grazing period after sowing. This was followed by Milgarra (3/9) with both types considered to grow well and were palatable to cattle. Temprano was the least preferred legume (8/9) with farmers indicating slow regrowth and poor survival. Two farmers had started to transplant grasses (Mulato), one of these had fully expanded his nursery with Mulato, whilst no farmers had started to propagate legumes outside of the plot area. The reason for the lack of expansion of the new forages was that no dedicated areas for pasture improvement had been fenced.

The activity demonstrated that a large number of farmers were interested in new information and appreciated the opportunity to test new technologies on their own farm. However, few farmers were able to maintain the plots and fewer still were able to use the materials to improve the pasture base throughout the farm. The plots were designed to provide a nursery area that would provide sufficient vegetative or seed material to develop 1 ha of land. As most farmers were unable to maintain the 20 x 20 m plot, or at least considered it laborious, it appears that developing 1 ha of improved forage will be a challenge unless it was extremely well planned and resourced, with the expected outcomes and range of options clearly extended to the farmers. The challenges that farmers will face in establishing such a site would include fencing a small area of land (0.5 to 1 ha initially) and labour inputs for land preparation, sowing, weeding and fence maintenance. A smaller area, such as a legume bank for weaners, is likely to be the easiest option for cow-calf producers within coconut plantations.

Subsequently those farmers (n=3) that demonstrated good participation in the forage plot evaluations were engaged with the project to develop small (0.5 to 1 ha) strategic areas of forage legumes (Milgarra, Greenleaf, and Cowpea) to create a forage legume bank for calves and weaners. This was deemed a more feasible option for smallholders opposed to the more daunting development of large areas of improved grasses and/or legume mixtures. The legumes were selected to provide a diverse mixture of annuals and perennials, weed control, and ease of establishment (large seed, vegetative propagation). Sites were sown between October- and December-2019.

Conclusions and recommendations

Farmers are willing to participate in on-farm research trials in Vanuatu, but their level of engagement is largely dependent on available time. Scale-out of on-farm demonstration sites within the farm requires detailed planning which will require training. Scale-out to other farmers will depend on cross-visits to good forage sites, which occurred at only a limited level within the current project. Farmer field days generated further interest amongst a larger number of farmers to develop small areas of improved forages for strategic feeding of young cattle. The Phase 2 project proposes to provide farmers with the skills to plan these farm improvement activities within the context of the available resources of the household.

Activity 2.4. Review of potential non-forage feed resources for cattle in Vanuatu conducted

Prepared by: Simon Quigley

Introduction

In most smallholder systems around the world the availability of non-forage agro-industrial by-products provides an important source of inexpensive feedstuffs for cattle, and other livestock species. These by-products are variable in quality and price but may be used as supplements to address a specific nutrient deficiency or combined to formulate complete rations on either a targeted diet quality or least-cost basis. In the more intensive crop-livestock systems that exist throughout Asia these non-forage feed resources often comprise the majority of the diets fed to cattle.

In Vanuatu, cattle are exclusively grazed on pastures, with little to no supplementation, intensive feed lotting, or stall feeding occurring. In addition, there is limited access to agro-industrial by-products due to the limited manufacturing sector and centralised processing locations. Cattle grazing pastures in the wet tropics may face a protein deficiency in the dry season or an energy deficiency in the wet season (due to an increased water content of pastures). There are a limited number of non-forage feed resources available for cattle feeds in Vanuatu. Whilst the opportunities to access non-forage feed resources is limited in Vanuatu compared with other Pacific island countries where Palm Oil (Solomon Islands; palm kernel cake, palm fronds), sugar (Fiji; molasses, bagasse, cane tops), fisheries (Solomon islands; fish meal), and noni (Samoa; noni juice extract) industries are established, a review of the current and emerging feed resources was warranted. The review identified opportunities to utilise these materials as supplements or in complete rations for cattle, and the collation of data will also provide local Livestock officers with information that may be useful in formulating rations for small livestock using local materials.

Materials and methods

Potentially useful non-forage feed resources were identified in consultation with Department of Livestock officers in various meetings in the early stages of the project. Nutritional databases (Feedipedia, DairyOne) and existing publications (particularly the review of Aregheore which comprehensively reviews both forage and non-forage feed resources across the Pacific island countries), were accessed to collate information on the nutritional value of various feedstuffs.

In addition, representative samples of some feedstuffs were sourced and dried to a constant weight at 60°C prior to import to The University of Queensland in accordance with import permit conditions (namely gamma irradiation at 50 kGy prior to release from quarantine). Samples were analysed for organic matter, crude protein, neutral detergent fibre, ether extract (lipid), and a range of minerals (Ca, P, K, Na, Mg, Mn, Zn, Cu, Fe). Where available, national production statistics and trends were sourced from various trade and census data (VNSO, 2007; VNSO, 2016).

Given the limited availability of non-forage feed resources a more detailed laboratory analysis of the composition of native and introduced grass and legumes was undertaken to provide local data on feeds that would be more accessible to smallholder farmers. A database of the nutritive value of approximately 80 feedstuffs was generated.

Results and discussion

There was limited data regarding production and availability of the various feedstuffs reviewed. For this analysis potential non-forage feeds were broken down into two main categories:

1. *Subsistence crops*

These potential non-forage feed resources were derived from crops grown typically in private gardens for subsistence, and included the tuber and leaves of root crops (yam, taro, sweet potato, and cassava), island cabbage, peanuts (stover), maize (grain and stover), and fruits (banana, papaya, and pineapple). Data on the production of these crops, and hence potential use as cattle feeds, is limited given the most recent Agriculture Census was conducted in 2007 and only reports the number of households growing crops. These crops generally have high a carbohydrate content, with low crude protein and fibre content (refer to database). Whilst these energy dense ingredients would be of value in any livestock (ruminant or monogastric) feed, competition from human consumption, importance in food security after natural disasters, attached traditional and social values, and the small scale, non-commercial and geographically dispersed/fragmented production systems mean these are unlikely to have any significant role as non-forage feeds for cattle on a broad scale in the short- to medium-term.

Whilst these products are typically grown and utilised for human consumption and cash flow from local markets, that does not preclude their use in livestock feeds or within livestock production systems on some occasions. For example, a small business on Malekula purchases excess banana and cassava that is unsold after local market days and includes these in locally produced rations for poultry and pigs that are less expensive than imported rations. In this model, farmers receive income from their goods that otherwise would have been transported back to the farm. The business also offers a small price incentive to farmers who do some value-add processing (sun-dry) of their products that are excess to demand. The integration of these and cash crops (e.g. kava) into the farming system may provide dual-purpose opportunities that could be explored. For example, grazing sweet potato leaf before harvest of tubers for human consumption or developing new grazing lands after cassava (short-term) or kava (longer-term) harvest, where an extended period of weed control has been completed throughout the production cycle.

2. *Agro-industrial by-products*

Due to a larger scale of production and centralisation, several by-products from commercial production and processing may have potential as non-forage feed stuffs for cattle in Vanuatu. These include copra meal, cocoa hulls, and brewers grain. At a much smaller scale, Canarium meal and Noni juice waste may be relevant at a local level in the future.

Copra meal is the largest commercially available non-forage feed source in Vanuatu. It is high in protein and energy (due largely to residual lipids after oil extraction) and as such has the potential to be used as a protein supplement for cattle grazing protein deficient pastures in the dry season. Liveweight responses of young growing cattle to copra meal in northern Australia are variable but generally increase in a curve-linear fashion (McLennan,2004). Low intakes have been reported in some instances, and this was addressed through the inclusion of additional starch in the diet (sorghum grain: Da Silva, 2017).

The largest producer of copra meal in Vanuatu is the Coconut Oil Production Santo Limited (COPSL) located in Luganville. Exports of copra and copra meal (as a proxy for production) from Vanuatu have declined significantly in recent years (Figure A2.24). This decline has occurred despite increased export demand from Australia and New Zealand due to diminishing availability of locally available plant-based protein supplements in those countries. Availability is largely dictated by smallholder harvest which fluctuates over the short-term in response to global copra prices but has a long-term declining trend due to the age and yield of established plantations (Figure A2.25). It is reported that only 42% of all coconuts are formally harvested, with the remaining 58% left on the ground in plantations (Vanuatu Department of Agriculture and Rural Development, 2016). It is believed that most available copra meal is exported, with small quantities retained and utilised in small-scale commercial poultry and pig production systems. Previously, the use of copra meal was limited due to the high lipid content and rancidity that resulted from storage in the wet tropics. However, more efficient extraction methods make this a more feasible, if not expensive, feedstuff for cattle. The COPSL copra meal tested in the current project fell within the range of reported values for copra meal in the various feeding standards.

Copra meal currently trades at 40,000 vatu/T locally (Santo; 1000 vatu/25 kg bag), and retails for AU$600/T in Australia. At these prices it is unlikely that smallholder cattle farmers in Vanuatu would purchase copra meal as a supplement or an ingredient in a complete ration for cattle in Vanuatu. Other coconut by-products with potential as feedstuffs include unprocessed copra and makasse (copra waste after virgin oil extraction).

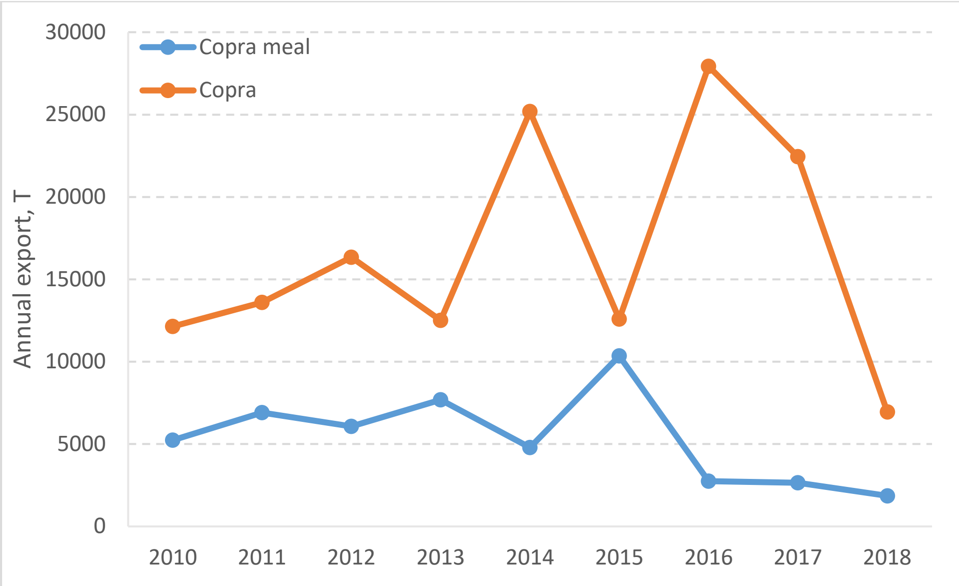


Figure A2.24. Copra and copra exports from Vanuatu, 2010 to 2018. (Source: VNSO Trade Reports).

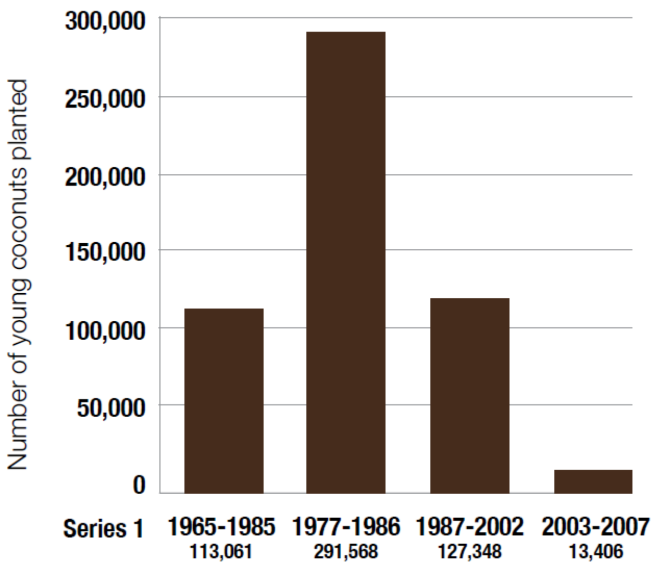


Figure A2.25. Coconut plantings. (Source: Vanuatu National Coconut Strategy 2016-2025, DARD; original data from VNSO, Ag Census, 2007).

Cocoa production is highly variable between years but has increased over the last decade in Vanuatu (Figure A2.26). The main cocoa production islands of Santo (32% of national cocoa production) and Malekula (49% of national cocoa production) also have the highest cattle population. Cocoa pods, left in the field after fruit harvest, provide a large biomass of high fibre, low protein, and energy material. Whilst cocoa-pods will be consumed by cattle they are a maintenance feed at best. Cocoa hulls (skins), removed from the cocoa beans after roasting, are higher in quality than cocoa pods but availability remains low due to the small quantities produced after roasting and processing occurs in centralised locations rather than at point of origin. There is limited potential for either of these products as non-forage cattle feeds in Vanuatu due to quality and quantity constraints.

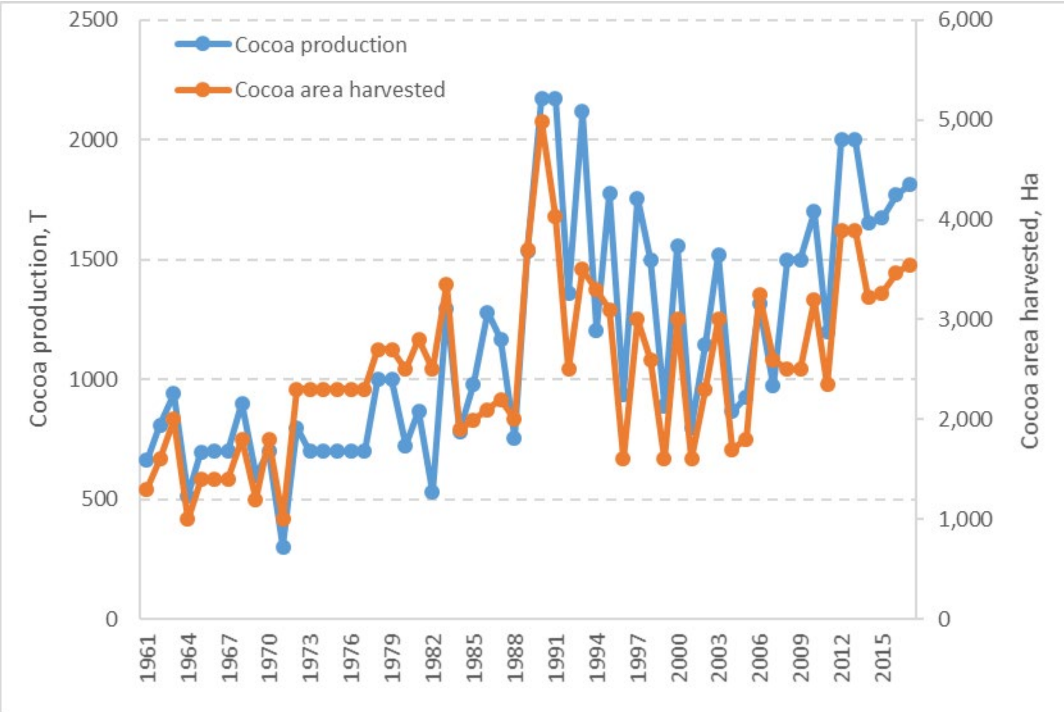


Figure A2.26. Cocoa production and area harvested in Vanuatu. (Source: FAOSTAT).

Canarium (*Canarium indicum*) trees are indigenous to Vanuatu and 'Nangai' nuts have long been collected from both wild and commercial plantations by smallholders. Nangai kernels provide a source of dietary protein and energy to rural households and have significant traditional values. Kernels contain approximately 8% crude protein and 45 to 75% lipids. Kernels are either sold fresh locally, or dried and used in a range of foods (e.g. cookies, roasted kernels) or more recently for oil extraction (Nuts-N-Oils', Malekula) (PARDI, Canarium Nut Value Chain Review, 2011). Nuts-N-Oils currently purchase approximately 30 T of semi-dried Nangai nuts/year but could potentially purchase more (50 T/year). However, they are constrained by basic processing facilities and a limited storage capacity. The canarium meal tested by the project had a high crude protein (250 g/kg DM), P (12.5 g/kg DM), and K (17.5 g/kg DM) content. Despite the very high lipid content (350 to 650 g/kg DM), the product did not appear to go rancid during storage prior to use in rations at Nuts-N-Oils. The high lipid content is likely the result of inefficient oil extraction methods and could potentially be improved, increasing oil yield and decreasing lipid content in the by-product. At present the high lipid content and the small scale, localised production means this product has limited use as a cattle feed in Vanuatu in the short- to medium-term.

Noni (*Morinda citrifolia*) is also indigenous to the Pacific island countries and has long been grown and consumed for its 'reported' medicinal properties (immunity, stress, diabetes). Increased Noni plantings are occurring in Vanuatu, particularly on Santo. Chinese business interests have recently established large Noni plantations with local juice extraction proposed. Use of the waste product for livestock feed may present a value-add opportunity for these business interests. Limited research has been conducted on the use of Noni or its by-products as a feed for livestock. Yancy et al. (2013) reported a significant linear increase in average daily gain and higher efficiency of feed conversion when growing calves were fed a high grain ration (75% of total intake) top-dressed with Noni at either 0.09 or 0.18% of the total intake (on a dry matter basis). These authors also reported a reduction in white blood cell count in response to increased Noni inclusion in the diet but no effects on stress response of the calves were detected. It should be noted that this was work involved five replicates per level of Noni inclusion, inclusion levels were extremely low and the experiment was conducted over a relatively short period of time for a liveweight gain study (28-days). Similarly, Anantharaj et al. (2017) fed 100 g minced Noni fruit to young calves (60 to 70 kg liveweight; assuming 10% DM would equate to 10 g minced Noni fruit DM/calf, or ~0.015% liveweight on a DM basis). Again, the study was of a short duration (4 weeks) and focussed on biochemical and antioxidant responses with no production measures conducted. Noni extract reduced the concentration of cholesterol, triglycerides, glucose, urea, and creatinine in the blood of calves whilst superoxide dismutase and catalase concentration were increased. Areghoere (2005) fed goats a ration with 0, 25 and 35% Noni waste extract and observed a significant reduction in dry matter and ME intake and dry matter and protein digestibility, although no differences in liveweight gain were reported the growth study was only conducted over 21 days. At these higher inclusion rates Noni waste extract appears to have a negative effect on the palatability of the ration resulting in reduced intake which would likely result in lower liveweight gain period over an extended period of time. It should be noted in all these studies Noni extract was not used as a supplement for animals fed low quality rations but was included at low or moderate levels in balanced rations. Whilst the role of Noni as a supplement for ruminants fed low quality basal diets remains unknown the palatability issues reported by Areghoere (2005) are likely to preclude its use as a feedstuff for cattle in Vanuatu.

Brewers grain (spent grain) is a by-product from the Vanuatu Brewing Limited (Tusker) brewery in Port Vila. The brewery currently produces approximately 30 to 35 T of (fresh) brewers grain per month (7 T dry matter assuming 80% moisture content) with production on Wednesday and Thursday each week. The brewers grain is currently provided free to a small number of local chicken (2) and pig (3) farmers on Efate. Farmers provide their own storage bins and must collect the product with 48 hours of filling, whilst the farmers provide an animal back to the brewery each year as payment. Brewers grain is high in protein (200 to 300 g/kg DM) and ME (10 MJ/kg DM) and like all grain-based feeds has a high P and low Ca content. As a by-product of processing for human consumption it is unlikely to contain any contaminants and can be fed at high levels (20 to 35% inclusion rates in rations or as a supplement are common). It is commonly used as a high-quality ingredient in the rations of cattle where access to the product exists (selling at approximately $525/T of dry matter delivered in southeast QLD). The relatively high moisture content (75 to 80%) and low bulk density make storage and transport a challenge, restricting use to cattle in close proximity to the brewery. Whilst drying increases storage life it is energy inefficient and storage would remain a challenge in the wet tropics of Vanuatu. Current production levels of 7 T dry matter per month (230 kg DM/day) would provide sufficient feed for approximately 65 head of steers (350 kg liveweight at 30% of the ration on a DM basis). At this stage it is unlikely that brewers grains would have any use as a cattle feed outside of Efate where the brewery is located. Whilst the brewery could charge farmers to purchase the brewers grain it would appear, they are happy with the existing relationship that results in the utilisation of a waste product with little input from the brewery.

Wheat is imported for processing in the bakeries of Vanuatu and is likely to result in wheat bran and other by-products. There is no information on the import quantities and end uses of by-products from the baking industry in Vanuatu.

Conclusions and recommendations

The potential use of non-forage feeds for cattle in Vanuatu appears limited due to the localised, small scale of production, a limited manufacture and processing sector (so limited opportunity for value-adding), and competition from human requirements. Copra meal is the only non-forage feed source produced in sufficient quantities to make any significant contribution to the nutrition of cattle at a broad scale. However, declining production, high export prices and transport and storage logistics in the wet tropics mean this is an unlikely feeding option for smallholder cattle farmers Vanuatu in the future. The use of unharvested coconuts that are otherwise wasted in the field may warrant further investigation, but this use would have high labour inputs for the collection and opening of coconuts to provide flesh for cattle to consume. In addition, the high lipid content may also result in low intakes. The potential development of dual-purpose systems for some of these crops (e.g. sweet potato and cassava) warrants research.

Activity 2.5. Assess the suitability of new cattle and pasture management software, databases and "apps" to assist with farm management decisions

Prepared by: Simon Quigley

Introduction

Like most developing countries, the use of hand-held digital devices is increasing rapidly in Vanuatu. The communications networks, whilst limited, are improving with increasing network coverage evident over the period 2016 to 2019. These developments open opportunities for the use of digital technologies to engage, train, and assist farmers with their farm planning, management, and marketing decisions.

This research activity was originally proposed to evaluate a number of alternative digital methods to collect research data within the Bisnis Blong Buluk project and include an assessment of transferability to farmers. However, in the early stages of the project and after discussions with ACIAR the project opted to participate in an overarching ACIAR project investigating the potential use of 'apps' in ACIAR funded research projects (Roxborough et al., 2017). The project adopted the use of CommCare software (Dimagi; https://www.dimagi.com/commcare/) for the majority of its data capture, as a result no other app's were specifically tested in the field. The following summarises the use of CommCare by the project team and presents a simple desktop analysis of the potential use of other apps and digital technologies to assist smallholder cattle farmers in Vanuatu.

Materials and methods

CommCare experiences

The project team provided comprehensive interviews and data to the overarching ACIAR project on experiences with the CommCare app. The use of CommCare was proposed as a method to increase the efficiency and accuracy of data collection, and allow for the generation of data summaries in near real-time for various levels of engagement (Figure A2.27). The surveys used a combination of text, integer, checkbox, multi-choice, lookup tables, image capture, and GPS questions.

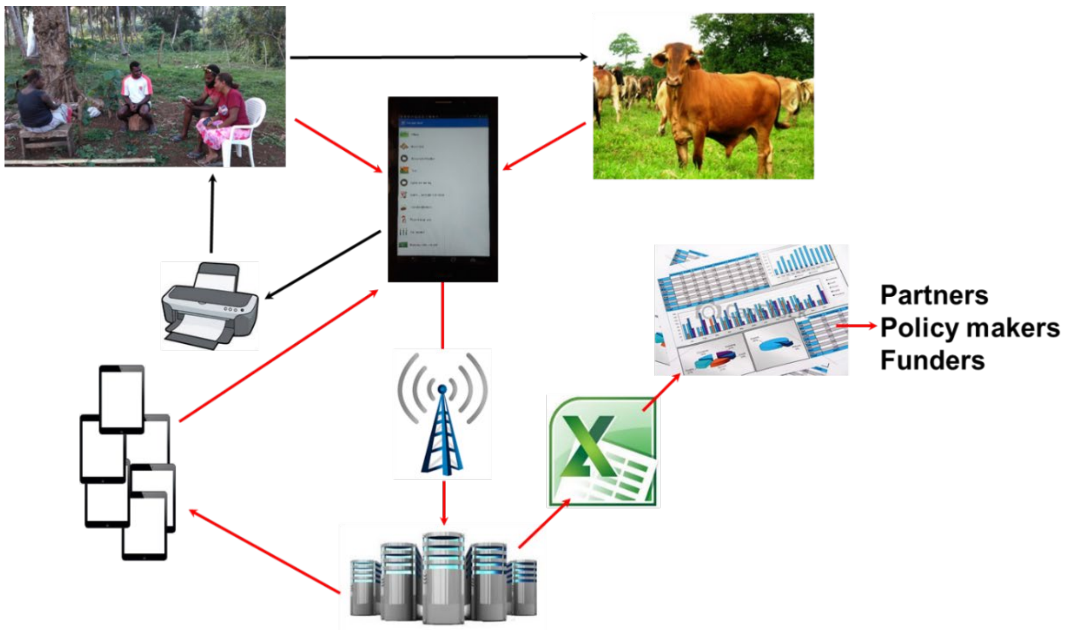


Figure A2.27. Proposed data collection, analysis, and dissemination pipeline using CommCare.

The general structure of the surveys included:

1. Village
    - Village description
2. Household
    - Access to agricultural services and information
    - Livestock inventory
    - Cattle feeding practices
    - Farmer problem identification and training requirements
    - Cattle mob monitoring
    - On-farm pasture demonstration plot surveys
3. Household member
    - Description of household demographics
    - Livelihoods indicators
    - Commodity importance
    - Income and Loans
    - Non-timber forestry
    - Local organisations, community events and social obligations
4. Farm
    - Farm location and size
    - Farm attributes and infrastructure
    - Cash crop activities (copra, kava, trees)
5. Cattle
    - Individual cattle monitoring
    - Individual cattle missing at monitoring
    - Farmer feedback – liveweight and value
    - Farmer feedback – weaning recommendation
6. Stand alone
    - Project enquiries
    - Event attendance

Alternative digital technologies

A review of various app stores and digital technology reviews, and databases was undertaken to identify apps that may have relevance to smallholder cattle farmers in Vanuatu. The following search terms were used:

- Cattle monitoring, management and support,
- Pasture monitoring, management and support,
- Weed identification and management,
- Market reports; commodity trading,
- Weather forecasting, and
- Farm mapping (area calculations).

Identified apps were then further assessed on the following criteria:

- Approved for International use (by publisher),
- Free (or low cost); ongoing access fee's,
- Network requirements, Work offline,
- Ease of use (including requirements for associated technology),
- Relevance to tropical cattle production systems, and
- Security of data.

Results and discussion

CommCare

For formal results on the use of CommCare by the project team refer to Roxborough et al. (2017) which provides a summary of the project teams experience using CommCare when undertaking research with smallholder farmers in Vanuatu. The results as reported in that final report are provided here for reference, but readers should refer to and cite the full report by Roxborough et al. (2017).

User experiences

Research Staff

Staff in the Vanuatu Beef project found the planning and training phases of MAD implementation either 'easy' or 'normal'. However, staff members often found application building and testing 'difficult'. Many found deployment work to be an 'easy' or 'normal' task, while the few staff that did data management and monitoring found varied in their experience recording it as either 'normal', 'difficult' or 'very difficult'. AgImpact support was mostly regarded as 'very useful' by project staff, with most other support provision being rates as 'useful'.

Enumerators

Baseline and endline surveys of enumerators showed confidence among this small team in the MAD applications potential to change interviewer-farmer relationships and improve the survey experience. Almost all respondents (80%) believed interview-farmer relationships would change from the use of MAD applications before fieldwork, and all agreed with this after it was completed. All believed that MAD apps would make it easier to conduct surveys and reduce the time needed to do so, both before and after fieldwork. While only 60% believed apps would lead to improved accuracy of data collection before fieldwork, this increased to 80% afterwards.

What were the benefits?

MAD implementation in the Vanuatu Beef project led to benefits for the participants, field staff, research staff, data quality, and community perception of the project.

Relationship with participants and community

The clearest benefit to the project in adopting MAD was related to the use of in-form calculations and data tabulation on the device. These provided smallholders with on-the-spot printed information showing individual animal weight change and current market values across the herd. Both researchers and field staff commented that this activity improved relationships with smallholder participants, and the perception of the project in the community. Smallholders also indicated that they were making farm management decisions immediately based on the real-time market value information. They expressed disappointment that local extension officers in the area had used paper and never provided them with feedback.

Field staff experience

Field staff were particularly enthusiastic that their relationship with farmers had changed for the better through the use of MAD. Eighty percent said that their relationships with their supervisors had changed for the better. One hundred percent believed the app was easy to use, and their jobs had been made easier and faster by the introduction of the new technology. Eighty percent felt that the data collected was more accurate compared to data collected on paper. The fieldwork coordinator on Santo Island appreciated the opportunity to debrief with the project leader over the phone when the day's data had been reviewed.

Research staff

In choosing to develop, test, and maintain the application with limited support, the project leaders gained skills and experience in programming MAD apps, skills that they expect to use in future projects.

Data quality

The app added value in automating the field scale checks. Calculations were included to determine and advise if the degree of variability versus bathroom scales was significant enough that a recalibration was necessary.

Interdisciplinary collaboration

Building the application together changed the way the researchers communicated with each other and fostered collaboration between research disciplines. Owing to the fact that the various surveys were being delivered on one platform, the livelihoods and production sides of the research team were brought closer. This included each side providing comment on each other's survey sections, especially at the planning stage. In that sense, the MAD implementation helped increase interdisciplinary collaboration within the project.

What were the challenges?

Time requirements

With the lead researchers taking on all the responsibility for implementation, MAD implementation was a time-expensive exercise for the project. A total of 75 days was spent on MAD activities between the two component leads who participated. While time spent on traditional data entry to Excel spreadsheets was saved (estimated to have taken 2 months, less than 75 days), this data entry could have been done by field staff. That meant that there was a net loss in research staff time from the adoption of MAD.

Design issues

Some of the structural design choices made during the initial development were not practical under field conditions. The use of a single form with looping sections for cattle registration was discarded by the second training session in favour of a one form per animal approach. This change reduced the potential for data loss. It also helped to manage situations where animals owned by different farmers were penned at the same time and herding an individual farmer's cattle through in sequence wasn't possible. Manually entered cattle ear tag IDs were replaced with app-generated tag IDs based on the farmer's initials. In the livelihood's component, forms that were initially being used at the household level needed to be linked to individual household members, to get a gender disaggregated perspective on some issues. These alterations meant considerable work was needed to amend the forms and application structure. Linking existing form data to respondents required a different approach to that taken with data collected after the changes were implemented. This was particularly so in the case of the livelihood component changes.

Shifting focus of staff

Dr Quigley felt that the focus on the devices and app during training meant that less emphasis was placed on the biological aspects of field staff skills. He suggested that other research related skills, like data entry and presentation in Excel, had been supplanted by the implementation of MAD. He remained concerned that the centralisation of data storage was limiting field staff's understanding of the farmers and animals but felt this could have been minimised by prioritising the creation of a data dashboard to share with the team.

Device issues in the field

It was discovered that the screens could become unresponsive when wet, and there was no shelter where cattle were being weighed. To resolve this the enumerators were supplied with rain covers for the devices.

Conclusion and key lessons

The project component leads felt that though they dedicated a lot of time to MAD adoption, and experienced quite a few logistical issues in the field. However, the lessons learned through this implementation experience will be invaluable when applied to future projects. Dr Quigley and Dr Addinsall proved that with just a few days training it is possible for researchers to build and deploy a large MAD application utilising sophisticated features. Most importantly, some of the innovative features they employed progressed the goals of the project and transformed the way farmers in the region think about participating in research. These features should serve as a model for feedback loops in MAD-capable projects. There is a trade off in skills (i.e. in data management by field staff) when adopting MAD technology that project leads should be aware of. Despite this, strategies exist for minimising any disconnect between field staff and the data.

Further lessons learned through this project include:

- Designing a suitable MAD application requires the consideration of field conditions, particularly the logistics involved when working with animals,
- Closing the feedback loop by utilising calculations to provide valuable real-time information to farmers has a very positive impact on smallholder relationships in research projects,
- There is value spending extra time at the planning stages, and in field testing an application before real data is collected, in order to minimise changes that could result in legacy data structures,
- Projects with in-depth, small scale data collection requirements may not see the time savings that can be expected at scale, but should consider partial MAD adoption for components that conduct regular monitoring, and
- Training workshops of three or more days are a viable method for upskilling researchers who would like to develop and deploy applications themselves.

Additional comments from the project team

The key finding was the project attempted to undertake an unnecessarily large amount of diverse data collection using CommCare for such a small project. The app itself became difficult to navigate due to the large number of surveys for such a small cohort of participants. The app sometimes lacked the flexibility required in the field, but this was rectified after pilot testing. There was a tendency for field staff to rush through surveys always conscious of imposition on farmers' time, as such not all options in check-lists were covered or farmers were not given enough time to respond accurately, and in hindsight there were too many surveys, questions, and options. The major issue the team had with the ongoing implementation of CommCare was that the project leader was largely responsible for troubleshooting and often unaware that there were problems with the app until it was too late.

The team always saw it as one of a range of tools available to support research, and it complimented other in-depth interviews and focus group discussion rather than replaced them. The key aspect and the primary reason for exploring the app was to develop a method to provide farmers with near real-time feedback on individual cattle that were presented at longitudinal monitoring events. This was largely successful with data printed in the field and provided to farmers the day measurements were taken (Figure A2.28). The data was expanded to include a local 'vatu' value per head (based on local market prices) in addition to some management suggestions on a per animal basis (e.g. calves of lactating cows at body condition score of 2 or lower should be weaned if high quality feed and drinking water is available). At the commencement, this was seen as an important step in engaging farmers in project activities.

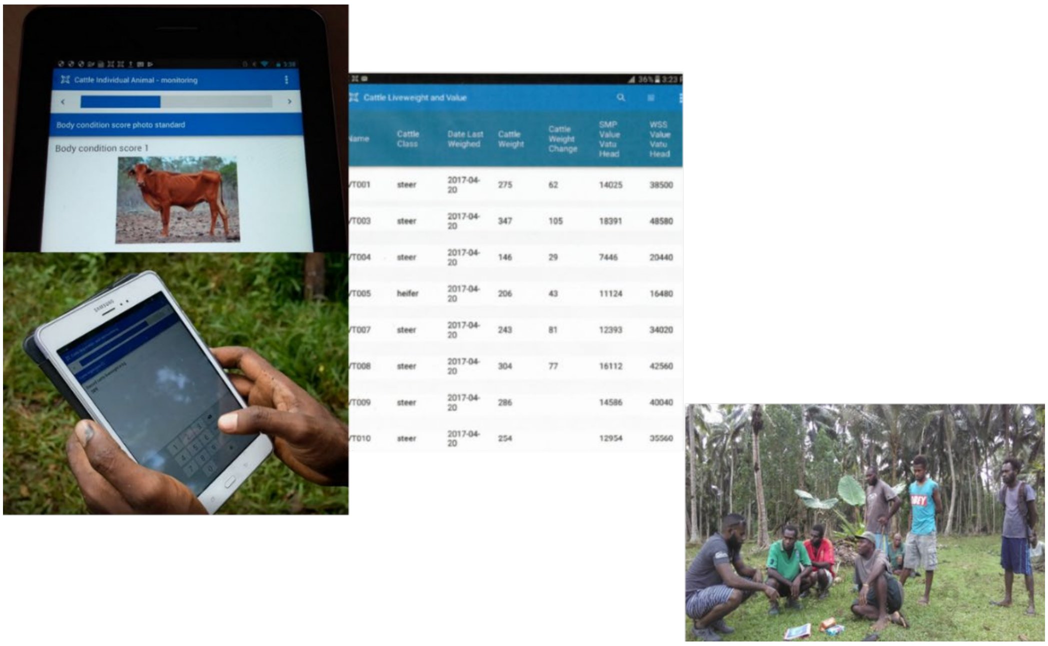


Figure A2.28. Collecting, printing and discussing animal level data with smallholder cattle farmers in Natawa village, East Santo Area Council.

The project team would certainly recommend the use of CommCare for some aspects of data collection again but would significantly reduce the number of surveys undertaken to focus on only those for basic enrolment and description data and any more intensive monitoring undertaken through brief, specific stand-alone surveys that do not require detailed parent-child case structures. In theory it would be an excellent decision support tool, and for use in monitoring and evaluation of the implementation of project activities, however this would have to be at a very basic level.

Digital apps

There are limited existing apps which would be directly transferable to smallholder cattle production systems in Vanuatu. Many of the cattle monitoring and nutrition or feed formulation apps were overly sophisticated, not relevant to the cattle management conditions in Vanuatu or required RFID connectivity to attain greater benefit, whilst pasture based apps were typically designed for use within temperate systems. Whilst marketing apps provided excellent information, these obviously only included market information relevant to Australian livestock. Unsurprisingly, none of the apps evaluated were in Bislama, which would obviously eliminate their use by the targeted users in Vanuatu. Nevertheless, there were features across all these apps that could be incorporated into apps developed for smallholder cattle farmers in Vanuatu. These features included:

- *Cow-calf* app uses a decision tree approach to develop a management plan for cattle when forage availability is low. This design is in line with the proposed Phase 2 project thinking on developing a simple diagnosis tool for extension workers to assist farmers identify problems and prioritise solutions,
- *Body condition score tool* app uses simple images to identify the mean body condition score of a herd of cows. The constraints with the current version are they it is developed for dairy cows, does not use a 1 to 5 scale, and requires a minimum of 70 records/mob to generate a report. Nevertheless, the approach could be modified and again may be of use to extension officers and farmers.
- *Cattle manager* app records very basic pedigree information on individual animals. It works off-line, requires no additional infrastructure and is easy to use. It does not record production, marketing, or health information, with the exception of vaccination records.
- *Ground-cover* app uses simple assessments of ground cover and user acquired photos to monitor changes in land condition over time. This concept could be adapted to assess

land condition on smallholder farms in Vanuatu which may be of use in identifying managers for engagement in larger government programs.

- *FarmGraze* app was developed for temperate systems in the UK so the recommendations are irrelevant to tropical grazing systems. However, it is very easy to use and provides good livestock management recommendations (stocking rate, rotation length) based on inputted data, which includes pasture height or biomass availability. Again, a locally based app could be formulated on similar principles using locally derived data
- *StocktakePlus* app was developed by the FutureBeef team with funding from Meat and Livestock Australia. It is relevant to the northern beef industry of Australia and is likely to be transferable to similar pasture-based systems in Vanuatu. However, it was unable to be assessed as it is only available via iOS.
- *Veterinary Handbook* app was developed by Meat and Livestock Australia and provides a searchable database of disease details, symptoms, treatment, and prevention options for cattle, sheep and goats. It has a small purchase free but is then available offline. It does not provide photos of various diseases, but the listing is comprehensive. A similar app would be of relevance to extension workers in Vanuatu if it contained information of locally relevant diseases (and potentially accompanying photos).
- *NSW WeedWise* and *SEQWeeds* apps both provide searchable databases for extensive lists of weeds, which include photos. The concept of taking a photo of a weed and uploading to a database for identification and management recommendations based on stage of growth, seasonal conditions and farming system does not appear to be available at this time.
- *Farmer 'wallets'* record income and expenditure by farm commodity and other criteria and may be a useful tool for farmers to plan farm improvements, prioritise inputs and access credit.

Locally based weather forecast apps specific to Vanuatu were not identified but may be of use to farmers when planning pasture and weed management activities. Locally based market reports or trader apps linking buyer-intermediaries-sellers also appear to be unavailable in Vanuatu at present. Apps that provide instructional videos appear to be absent and may be worth consideration for extension of best-bet management and marketing practices for cattle. Whilst social media is as popular in Vanuatu as any developing country, there appears to be no dedicated app linking cattle farmers, women farmers, and other community groups.

The concept of using apps and digital methods to engage, train and empower smallholder farmers has increased significantly over the last decade. However, there is limited published evidence of their impact on the productivity and profitability of smallholder farming systems and the livelihoods of household members (Baumuller, 2018). Baumeller (2018) identified only 23 publications that evaluated the use of 'm-services' and concluded that greatest impacts ensued from 'm-services' that resulted in improvements in production planning, mitigating weather risks, and providing ease of access to finance. In the Vanuatu context, the use of app's for smallholder farmers may initially appear appealing, however further evidence would be required before any such app build was undertaken. However, the development of apps to support extension workers with farm and herd assessments, problem diagnosis, weed/pest/disease identification, farm planning, and farmer training may be warranted.

Conclusions and recommendations

The CommCare app provided some advantages for the project team in that in all data was collected and stored using a consistent and centralised method. However, the project was attempting to use it for a diverse array of data and the maintenance and navigation of the app become cumbersome and inefficient. CommCare was suitable for much of the quantitative data collected, but it was often found to be inflexible in the field. It is recommended that future projects in Vanuatu consider the use of CommCare but only for more focused, specific surveys rather than an all-encompassing attempt to collect all data.

None of the currently available apps would be directly transferable to the context of the smallholder cattle production systems of Vanuatu at this time. The range of features in existing apps would be relevant if they were adapted to the local conditions (pastures, weeds, diseases, and cattle breeds). If locally relevant apps were to be developed, they would more likely be used to assist extension officers make farm and herd assessments to assist farmers improve their management practices. However, the use of digital media for training farmers through short instructional videos or decision support tools should be explored.

Activity 2.6. Conduct on-station research activities in Vanuatu

Experiment 1. Small plot evaluation of new and existing grass and legume lines for unshaded grazing by cattle in Vanuatu

Prepared by: Kendrick Cox

Introduction

The export of high-quality beef has considerable potential to benefit the economy and support livelihoods in the rural areas of Vanuatu. However, declines in the supply of cattle is limiting the capacity of processors to meet increasing demand. Sown pastures comprise the principal feedbase for beef production in Vanuatu, but productivity is variable. The species and cultivars of sown grasses and legumes used in the unshaded areas of Vanuatu are based primarily on older cultivars used in the wet tropics of Australia in the 1970s and 1980s (McFarlane and Shelton, 1986). Some of these (*Brachiaria decumbens, Centrosema pascuorum*) remain useful under current grazing management (regular uncontrolled grazing), whereas others (*Neonotonia wightii*) have declined. A range of newer grasses and legumes have been released in Australia and other parts of the tropical world which may be useful to smallholder farmers in Vanuatu. Some cultivars (e.g. Mulato 2 *Brachiaria* hybrid) have been introduced by large-scale graziers in Vanuatu, but there were no known studies to compare productivity with older types.

The first aim of this experiment was to compare the productivity (biomass and quality) of newer varieties of tropical pasture plants with older, previously adopted types and to use the results to promote adoption of the best options. A simple replicated study measuring biomass over a series of growth cycles was undertaken.

The second aim was to build local capacity in the identification, measurement, and agronomy of tropical grass-legume pastures (i.e. develop a pasture agronomy team), as these skills have been reduced considerably over the past 20 years. To achieve this, the research was conducted by a new research officer employed by the VARTC, project support staff, and students of the local agricultural college. The activity was used to demonstrate concepts in pasture management to farmers and students, and to identify grasses and legumes for a grazing-scale experiment used to demonstrate the effect of stocking rate on pasture and animal productivity.

Materials and methods

Management

A replicated small-plot experiment was established within a 1 ha fenced area at the VARTC, near Luganville on Santo in May-2016 and measurements continued until October-2018. The site, on an acidic, fertile black clay-loam soil (pHwater = 5.8, Colwell P = 28 mg/kg, sulphate S = 76 mg/kg), was previously used for grazing and the pasture comprised mostly of *Brachiaria decumbens* and *Centrosema pasacuorum*. The experiment layout is presented in Figure A2.29.

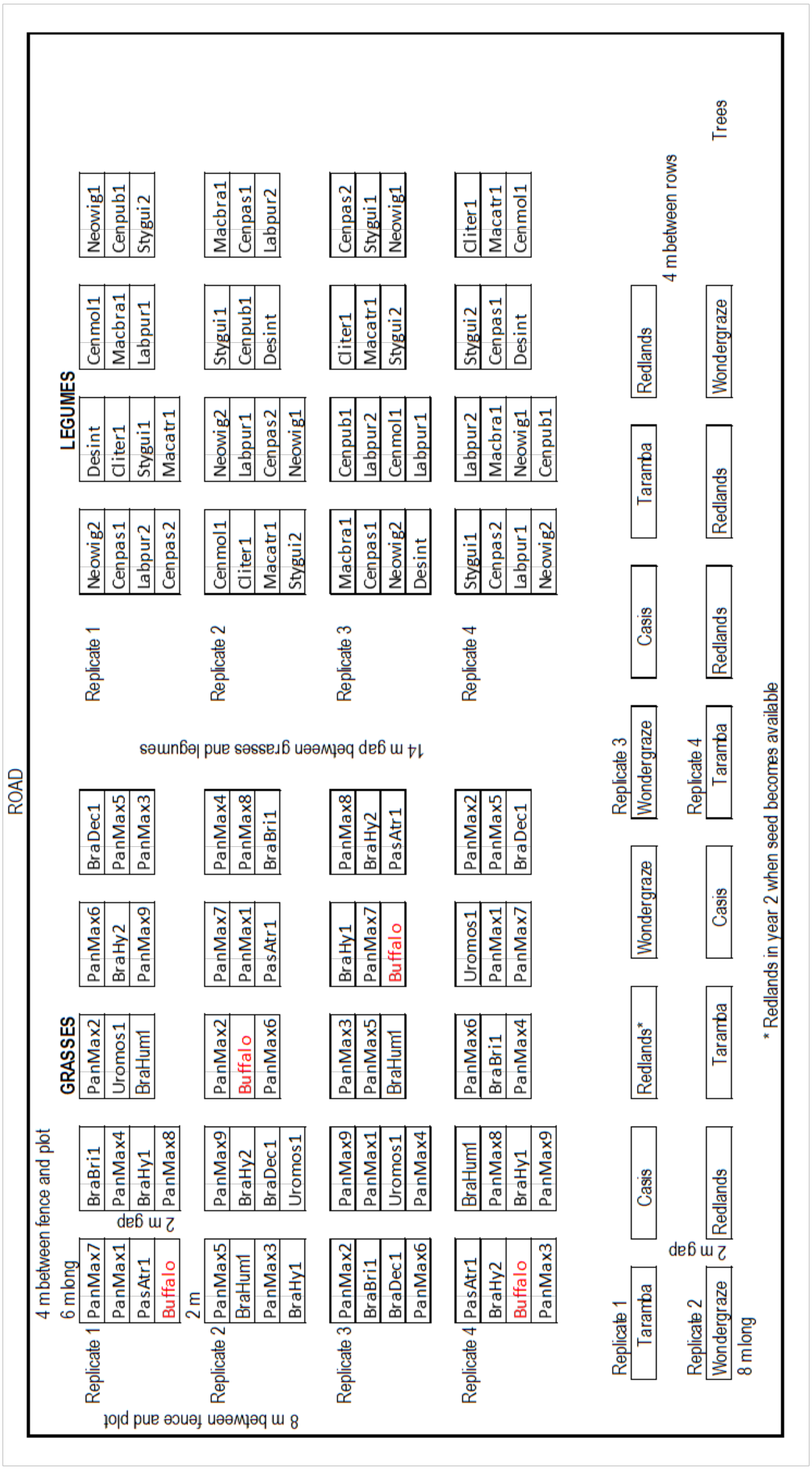


Figure A2.29. Experimental plan of replicated forage evaluation trial. Refer to Table A2.6 for codes.

The experiment comprised 17 grasses including *Brachiaria* (four species), *Panicum maximum*, *Paspalum atratum*, *Urochloa mosambicensis,* and *Stenotaphrum secondatum*; and 14 legumes including *Centrosema* (4), *Clitoria ternatea*, *Desmodium intortum*, *Macroptilium* (2), *Lablab purpureus*, *Neonotonia wightii,* and *Stylosanthes guianensis* (Table A2.6). The lines considered to represent local pasture plants included *Brachiaria decumbens*, *Stenotaphrum secondatum,* and *Centrosema pascuorum*. The remaining grasses and legumes included older varieties of grasses and legumes which have formed productive pastures in north Queensland for over 30 years (e.g. *Panicum maximum* (Gatton), *Neonotonia wightii* (Tinaroo)) plus a range of recently commercialised varieties (e.g. *Brachiaria brizantha* (Mekong), *Centrosema molle* (Cardillo), *Stylosanthes guianensis* (Nina, Temprano), and lines identified in the Tropical Forages^{TM} website as having potential in wet tropical areas and which had been previously grown for seed increase by the Queensland Department of Agriculture and Fisheries (DAF) (a range of *Panicum maximum*) at Walkamin in north Queensland.

The site was cultivated and sprayed with glyphosate at label rates to kill existing plants and produce a relatively level and friable seedbed (Figure A2.30). Raised beds were formed by hand, with each plot measuring 6 m x 1.4 m. Seeds were sourced from Australia, either through commercial purchase or (mostly) from stocks held by DAF at Walkamin. All lines were tested at DAF Walkamin for viability (top of paper, 35°C; 16L/8D) prior to shipment and the legumes treated for hard-seed dormancy where required. *Stenotaphrum secondatum* was sourced as ‘runners’ from VARTC. Establishment was originally intended for March-2016 but was delayed until 31-May-2016 due to excessively wet conditions.

Figure A2.30. Layout and pre-plant management of the experimental site at VARTC (top and middle) and established legume plots (bottom).

The grass and legume seeds were sown by hand into shallow furrows, in rows 30 cm apart, and were covered with soil. Sowing rate and depth varied with seed size (Table A2.6). The rows were gently compacted by foot. The legume seeds were not inoculated with nitrogen fixing bacteria. *Stenotaphrum secondatum* was vegetatively propagated. No fertilisers or irrigation were applied. Weeds were controlled by hand weeding. Pests or diseases were noted, but not controlled.

Table A2.6. Grasses and legumes included in the replicated pasture evaluation study at VARTC, 2016-18.

Species	Cultivar	Code	Sowing depth (cm)	Sowing rate (g/plot)
		Grasses		
Bracharia humidicola	Tully	BraHum1	0.5	25
Brachiaria brizantha	Mekong	BraBri1	0.5	25
Brachiaria decumbens[1]	Basilisk	BraDec1	0.5	25
Brachiaria hybrid	Mulato 2	BraHy1	0.5	25
Brachiaria hybrid	S155	BraHy2	0.5	25
Panicum maximum	Gatton	PanMax1	0.5	25
Panicum maximum	G2	PanMax2	0.5	25
Panicum maximum	Mombaca	PanMax3	0.5	25
Panicum maximum	PukP8	PanMax4	0.5	25
Panicum maximum	T72	PanMax5	0.5	25
Panicum maximum	Tanzania 1	PanMax6	0.5	25
Panicum maximum	Vencedor	PanMax7	0.5	25
Panicum maximum	Petrie	PanMax8	0.5	25
Panicum maximum	T110	PanMax9	0.5	25
Paspalum atratum	Hi-Gane	PasAtr1	0.5	25
Urochloa mosambicensis	Nixon	Uromos1	0.5	25
Stenotaphrum secondatum[1]	Buffalo	Buff	N/A[2]	N/A[2]
		Legumes		
Centrosema molle	Cardillo	Cenmol1	1.0-2.0	25
Centrosema pascuroum[1]	Cavalcade	Cenpas1	1.0-2.0	25
Centrosema pascuroum	Bundey	Cenpas2	1.0-2.0	25
Centrosema pubescens	Belalto	Cenpub1	1.0-2.0	25
Clitoria ternatea	Milgarra	Cliter1	2.0	38
Macroptilium atropurpureum	Aztec	Macatr1	0.5-1.0	25
Desmodium intortum	Greenleaf	Desint	0.5-1.0	25
Lablab purpureus	Rongai	Labpur1	2.0-3.0	50
Lablab purpureus	Endurance	Labpur2	2.0-3.0	50
Macroptilium bracteatum	B1	Macbra1	0.5-1.0	25
Neonotonia wightii	Tinaroo	Neowig1	0.5-1.0	25
Neonotonia wightii	Cooper	Neowig2	0.5-1.0	25
Stylosanthes guianensis	Nina	Stygui1	0.5-1.0	25
Stylosanthes guianensis	Temprano	Stygui2	0.5-1.0	25

[1]Local comparator

[2]Planted vegetatively, three nodes in soil, two nodes above ground, one runner every 20 cm within a row

Measurements

The grasses and legumes were grown in a series of growth cycles and biomass production measured over each cycle using conventional methods of pasture sampling and processing (Figure A2.31; Table A2.7). The growth cycles were originally scheduled for 80 to 90 days, but excessive growth in the grasses prompted halving of the growth interval. Plant establishment was estimated eight weeks after sowing by visual assessments in two 1 m sections of row in each plot. For grasses, a 1 m ruler marked at 1 cm intervals was placed next to the row and the 1 cm sections containing plant bases were totalled (frequency). For legumes, the number of seedlings was simply counted in each 1 m length of row.

The following were measured at the end of each growth cycle:

- Live plant cover: a simple rating of the proportion of each plot occupied by a canopy of live herbage (0 = no cover, 10 = 100% cover),
- Plant biomass: dried (70°C until constant weight) biomass (g) of leaf and stem material harvested within two 0.7 x 0.7 m quadrats placed over the central two rows of each plot. The plant canopy was cut using either battery operated shears (mostly) or a sharp bush knife (occasionally). The field samples were weighed wet and dry and percentage dry matter calculated. Yields were converted to kg DM/ha. Live cover within each quadrat was estimated for use as a potential covariate for analysis. Cutting height varied with growth habit,
  - Legumes: 10 cm, except for the two *Stylosanthes guianensis* and *Lablab purpureus* varieties (20 cm), and
  - Grasses: 10 cm, except for *Brachiaria humidicola* and *Stenotaprum secondatum* (5 cm) and the taller *Panicum maximum* lines (Mombaca and T72) (20 cm),
- Growth observations: the timing of flowering and damage by pests or diseases, and
- Plant nutrient content: subsamples of biomass samples were collected from the grass and legume plots during March- and October-2018 and sorted into leaf and stem, with whole-plant samples imported to Australia under permit for proximate analysis (N, ash, NDF, ADF and minerals).

After each biomass sampling all remaining herbage biomass was cut using a slasher using the biomass sampling heights for each species and the material removed. Rainfall was measured on site.

Analysis

Simple summary statistics were calculated for each variable and presented as tables or plotted. Covariate analysis was conducted by a Queensland Government biometrician (Dr Carole Wright) using Genstat™ software to assess the effect of sample cover on biomass. In this analysis, the mean dry matter yield and quadrat cover were calculated for each plot and restricted maximum likelihood (REML) was used to produce adjusted means for total dry matter yield, which were then plotted.

Figure A2.31. The project team and students from the Vanuatu Agriculture College completing biomass harvesting at VARTC, March-2017.

Table A2.7. Timing of key measures within the plant evaluation study at VARTC, 2016-18.

Activity	Activity date		Growth period, days	
	Grass	Legume	Grass	Legume
Sowing	31-May-2016	31-May-2016		
Establishment	28-July-2016	28-July-2016		
Harvest 01	11-Nov-2016	12-Nov-2016	163	164
Harvest 02	28-Feb-2017	1-Mar-2017	85	86
Harvest 03	12-Apr-2017		35	
Harvest 04	06-Jun-2017	7-Jun-2017	41	91
Harvest 05	23-Aug-2017	24-Aug-2017	71	
Harvest 06	04-Oct-2017	5-Oct-2017	41	114
Harvest 07	20-Dec-2017	21-Dec-2017	69	70
Harvest 08	02-Feb-2018		43	
Harvest 09[1]	15-Mar-2018	16-Mar-2018	40	85
Harvest 10	08-May-2018		47	
Harvest 11	18-Jun-2018	19-Jun-2018	40	95
Harvest 12	06-Sep-2018		49	
Harvest 13[1]	22-Oct-2018	22-Oct-2018		

[1]Sampling for nutrient analysis

Results and discussion

The assessments were conducted over 29 months and included two wet seasons of growth by established (>6 months old) plants. Growth (and re-growth) was exceptional over this period for most grasses and legumes. The harvesting (growth cycle) interval for the grasses was reduced because of excessive biomass, which was not considered to represent plant growth stages normally fed to cattle.

Seasonal conditions

Rainfall was high (>1500 mm per annum) over the experimental period and was similar to long-term records for the area (Figure A2.32). Rainfall was highest between November and April, with only moderate rainfall (< 50 mm/month) recorded during between May and August in some years. Low levels of soil moisture may have been limiting for growth during this period, but no plants showed signs of excessive water stress during the experiment. Although not recorded at the site, temperature was typical of areas of low elevation within the humid tropics and was not considered to have significantly limited plant growth.

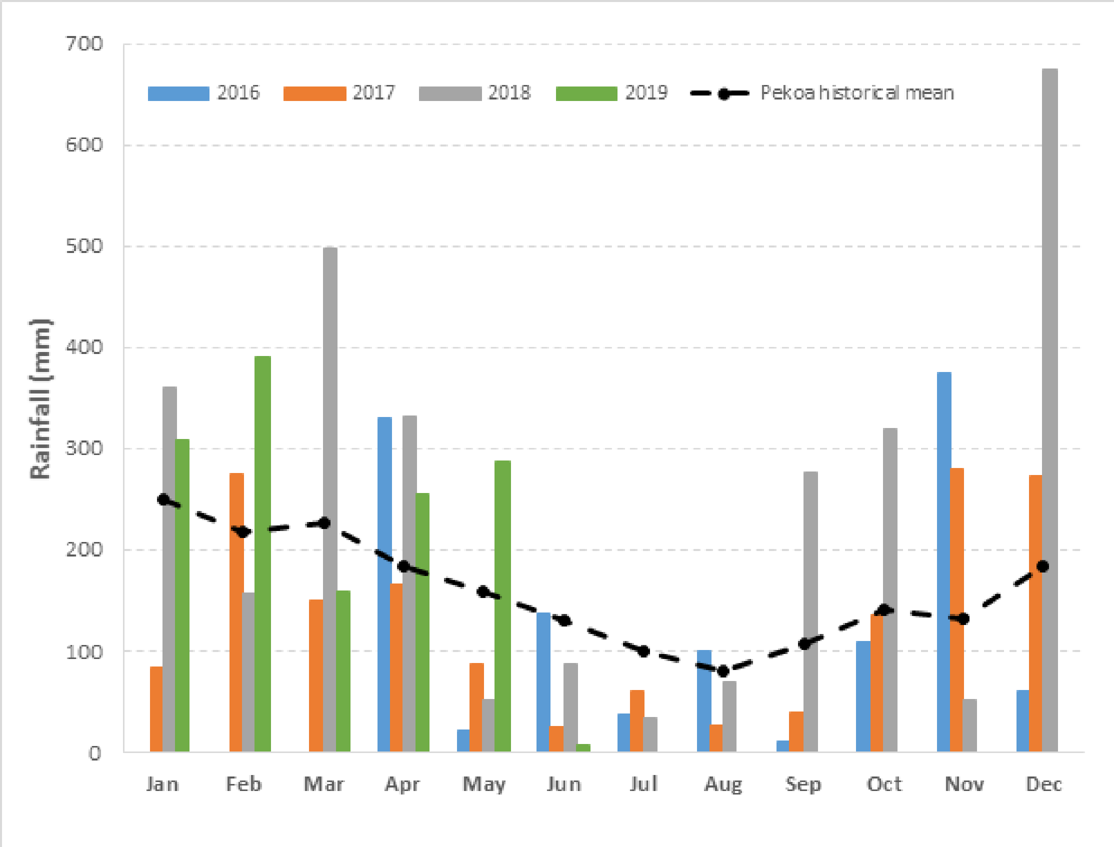


Figure A2.32. Rainfall at VARTC over the period of the experiment.

Establishment and plant growth

Initial plant establishment was assessed for the grasses and legumes eight weeks after sowing (Table A2.8). Establishment was excellent for all of the legumes, except the small-seeded *Stylosanthes guianensis* and two replicates of *Desmodium intortum.* Establishment of the *S. guianensis* lines continued after assessment and all plots were considered to have sufficient plant populations for assessment by October-2016. The grasses were slower to establish, and plant populations were more variable eight weeks after sowing. Despite often low initial plant populations, most had excellent cover by October (>80% of each plot) due to excellent growth after establishment. Some *Panicum maximum* (notably Tanzania 1)*, Paspalum atratum* (Hi-Gane), and *Urochloa mosambicensis* (Nixon) did not recover as quickly. In-fill sowing was completed to improve cover in the rows, but this was only moderately successful as seedlings competed poorly with mature plants. Once established, vigorous grass and legume growth was maintained throughout the experiment (Figure A2.33 and Figure A2.34).

Table A2.8. Plant establishment 58 days after sowing. (% basal cover of row; mean ± standard error of the mean).

Grass	Line	% cover	Legume	Line	% cover
Brachiaria (syn *Urochloa*)			*Centrosema*		
- *brizantha*	Mekong	24.5 ± 12.1	- *molle*	Cardillo	28.9 ± 4.2
- *decumbens*	Basilisk	3.0 ± 1.5	- *pascuorum*	Bundey	4.0 ± 1.3
- *humidicola*	Tully	13.3 ± 3.2		Cavalcade	23.0 ± 2.7
- hybrid	Mulato 2	2.1 ± 0.7	- *pubescens*	Belalto	3.1 ± 0.5
	S155	9.0 ± 6.7	*Clitoria ternatea*		
Panicum maximum				Milgarra	14.9 ± 2.6
	G2	6.5 ± 3.5	*Desmodium intortum*		
	Gatton	1.4 ± 0.5		Greenleaf	41.0 ± 8.6
	Mombaca	26.9 ± 3.9	*Lablab purpureus*		
	Petrie	0.9 ± 0.6		Endurance	11.8 ± 1.1
	pukP8	5.6 ± 2.2		Rongai	13.3 ± 1.3
	T110	3.1 ± 1.3	*Macroptilium*		
	T72	43.1 ± 16.7	- *atropurpureum*	Aztec	34.1 ± 6.6
	Tanzania1	0.4 ± 0.3	- *bracteatum*	B1	48.4 ± 8.2
	Vencedor	5.5 ± 1.9	*Neonotonia wightii*		
Paspalum atratum				Cooper	18.0 ± 7.7
	Hi-Gane	1.4 ± 0.7		Tinaroo	33.6 ± 5.3
Stenotaphrum secondatum			*Stylosanthes guianensis*		
	Buffalo	1.3 ± 0.3		Nina	5.0 ± 5.0
Urochloa mosambicensis				Temprano	0.0 ± 0.0
	Nixon	4.3 ± 0.8			

Figure A2.33. The grass plots and some of the better performing cultivars, September-2017.

Figure A2.34. The legume plots and some better performing cultivars, September-2017.

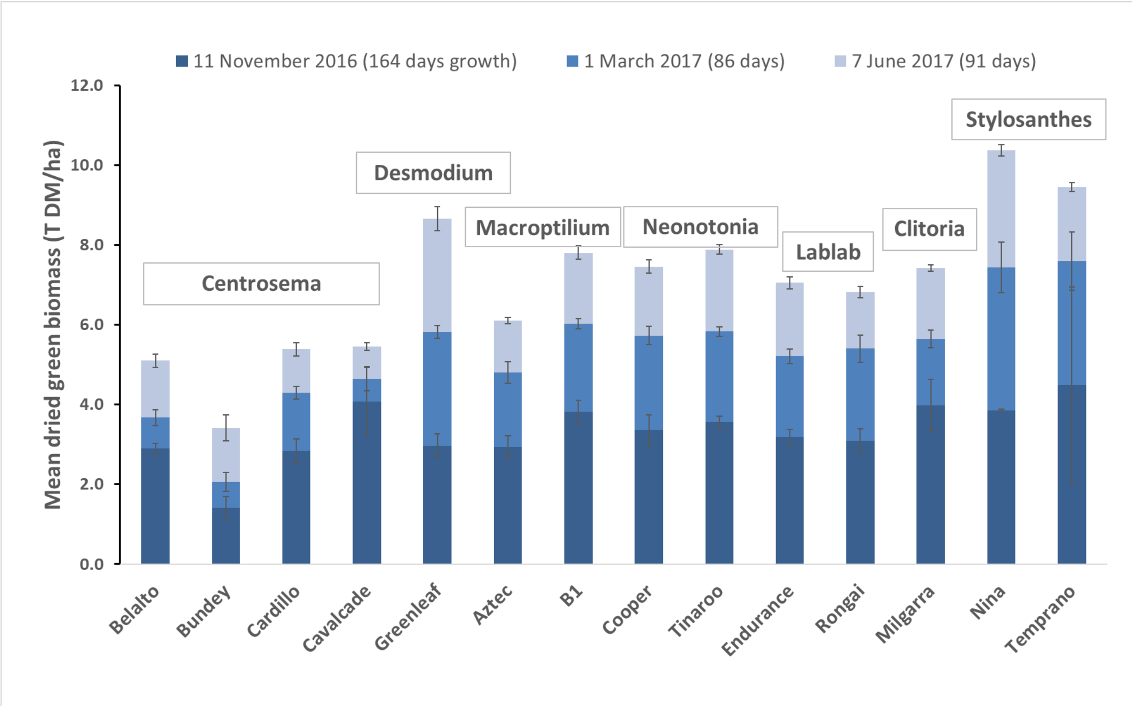
Herbage yields

Legumes

First year legume herbage production was measured over three growth cycles (134, 86 and 91 days, in succession). Herbage yields were high overall, ranging from 3.6 to over 10 T DM/ha (Figure A2.35). Highest production occurred in the *Stylosanthes guianensis* cultivars (Nina and Temprano) despite having low initial plant populations. Other legumes with high biomass yields included Greenleaf (*Desmodium intortum*), Cooper and Tinaroo (*Neonotonia wightii)*, Milgarra (*Clitoria ternatea*), B1 (*Macroptilium bracteatum*), and Endurance and Rongai (*Lablab purpureus)*. These legumes yielded well due to excellent regrowth after cutting in the first year. High growth rates and recovery from cutting was maintained over the experiment in these legumes, with over 20 T DM/ha produced by the *Stylosanthes* and *Desmodium* lines, over 15 T DM/ha by *Neonotonia* and a range of legumes producing 10-15 T DM/ha (Figure A2.35). Regrowth after cutting was poor in the *Centrosema* spp. during the establishment year, but *Centrosema molle* and *C. pascuorum* produced similar yields to many legumes towards the end of the experiment.

Grasses

Grass yields were higher than for the legumes, overall, with up to 50 T DM/ha produced over the experiment. Four regrowth cycles were completed in the year after establishment (Figure A2.36). The highest yielding grasses included lines of *Panicum maximum* (T72, Vencedor, Mombaca), Mekong (*Brachiaria brizantha*), and Hi-Gane (*Paspalum atratum)*. Yields within *Panicum maximum* lines varied considerably with lines currently produced in Australia (Gatton, Petrie) yielding less than others yet to be commercialised in Australia. The high yielding T72 had a substantially different growth habit to the other lines, being exceptionally tall (>2 m) under extended regrowth periods and producing broad and relatively coarse leaves. The principal local comparator Basilisk (*Brachiaria decumbens*) grew well after cutting, but herbage yields (14 T DM/ha) were lower than many of the other grasses evaluated. The relatively recently commercialised Mulato 2, out-yielded Basilisk. The other local comparator, *Stenotaphrum secondatum*, grew vigorously but biomass yields of this low growing grass were very low compared to the other grasses. This may be partly due to the sampling methods employed, which did not account for herbage below 5 cm, but overall biomass production was considered extremely low. The relative performance of these lines remained similar until the end of the experiment (Figure A2.36). The highest yielding of the commercially available (Australia) lines was Mekong (*Brachiaria brizantha*), followed by Mulato 2 (although seed production has been unreliable in recent years), and Basilisk (*Brachiaria decumbens*). A range of *Panicum maximum* produced similar or higher yields, but these are not commercially available.



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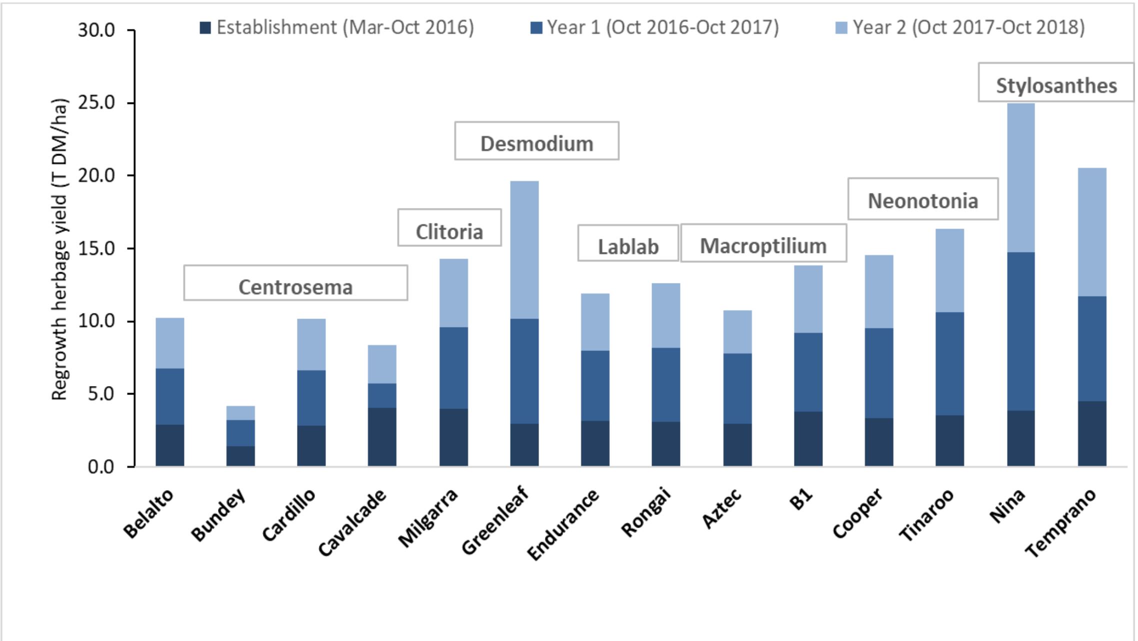
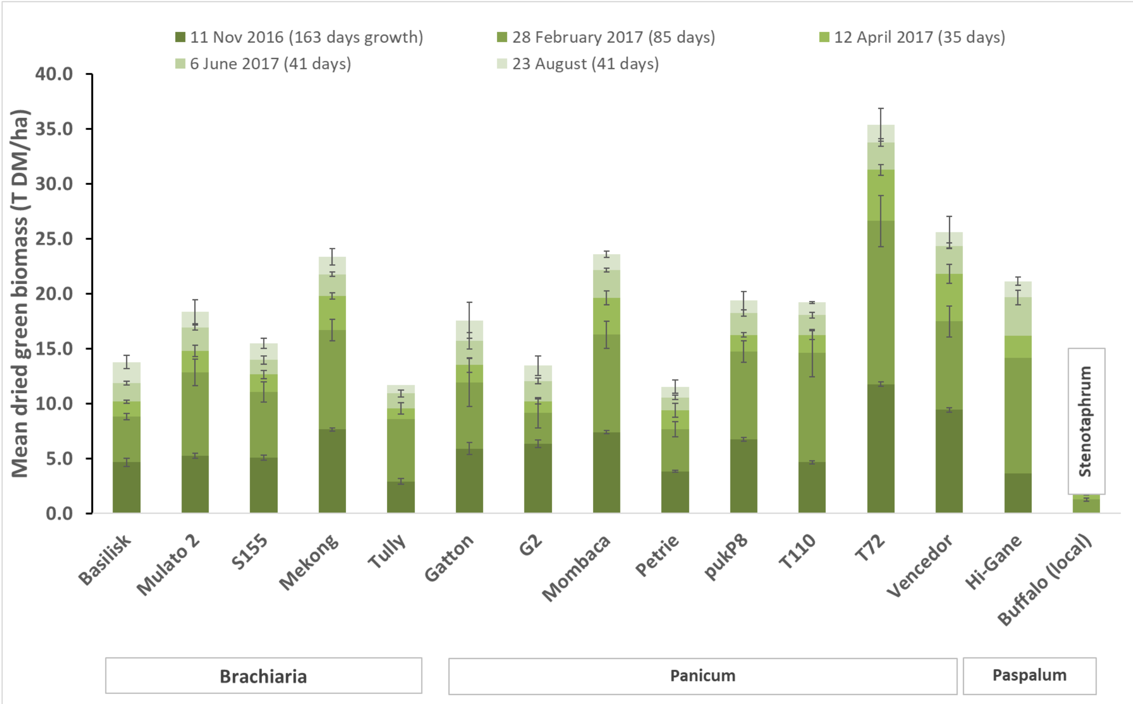
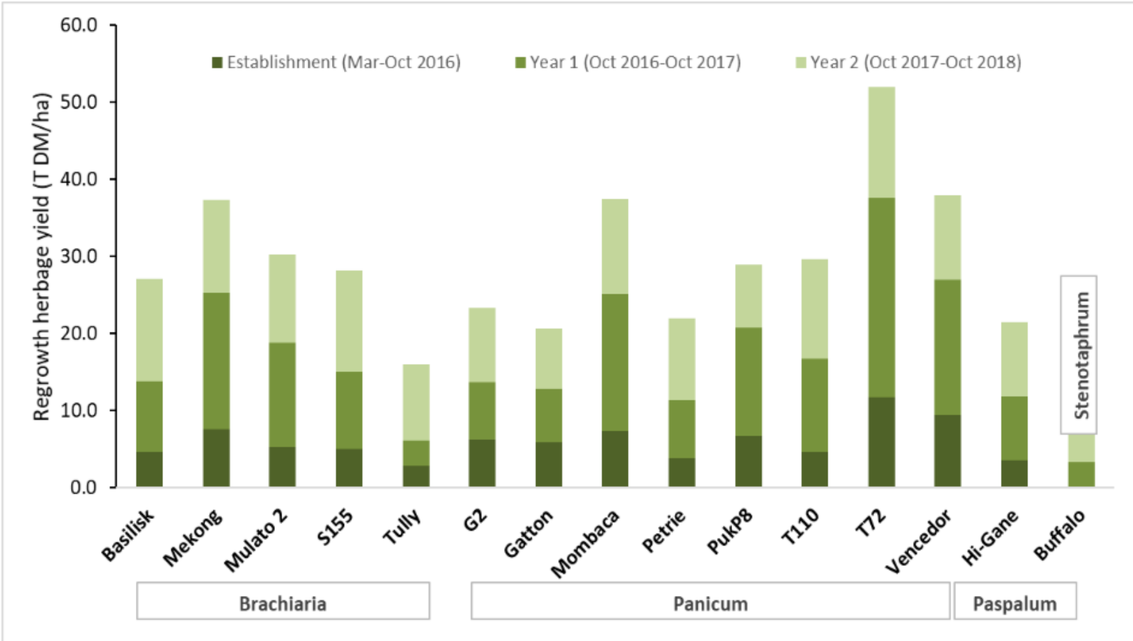


b.

Figure A2.35. Cumulative biomass production of legumes over one (a.) or two years (b.).



a.



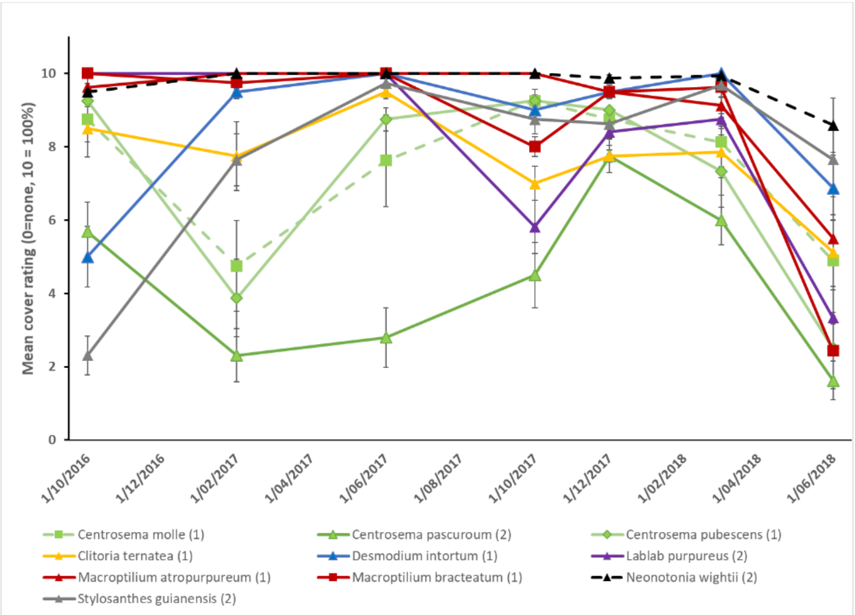
b.

Figure A2.36. Cumulative biomass production of grasses over one (a.) or two years (b.).

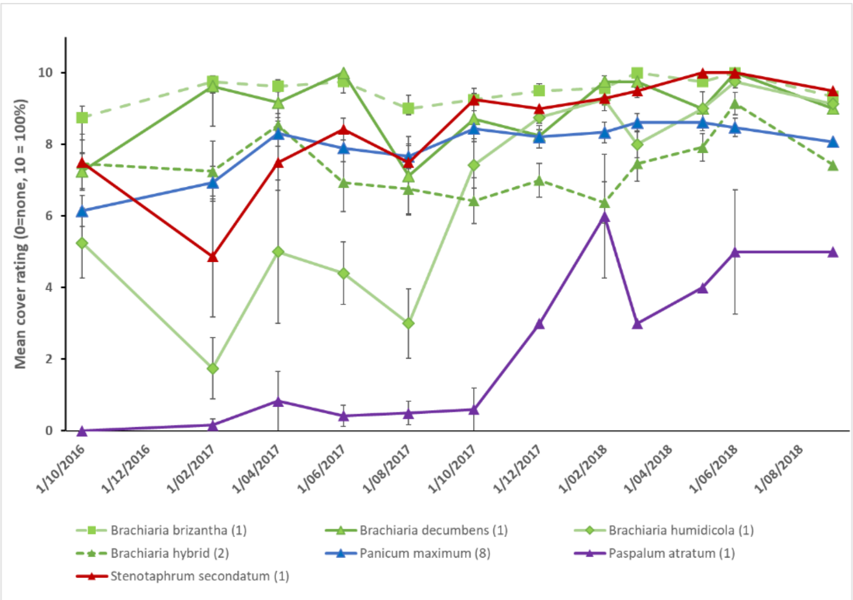
Changes in ground cover

The legumes had high levels of cover over the two seasons of assessment, with most over 70% during the first year of growth (Figure A2.37). Those with initially low cover values (*Centrosema pascuorum, Desmodium intortum,* and *Stylosanthes guianensis*) all achieved in excess of 75% cover. Persistence was high in the perennial legumes, as expected, but was also maintained until the end of the experiment by the legumes normally regarded to have shorter lifespans (*Centrosema pascuorum* and *Lablab purpureus*). The decline in cover of these annual types was associated with damage to leaves and stems by chewing insects and leaf fungal diseases. Yellowing and distortion of leaves was also recorded in *Centrosema pascuorum* and insect damage in *C. molle*; both persisted until the end of the experiment. The legumes with high levels of cover and dense, healthy canopies by the end of the experiment included *Neonotonia wightii, Stylosanthes guianensis,* and *Desmodium intortum*. Legumes with moderate levels of cover included *Centrosema molle, Clitoria ternatea*, and *Macroptilium atropurpureum*.

Grass cover was also high, with all grasses increasing in cover over the experiment (Figure A2.37). Most grasses had greater than 80% cover one year after sowing. The exceptions were Hi-Gane (*Paspalum atratum*) which only slowly increased in cover over the experiment, and Tanzania 1 (*Panicum maximum)* and Nixon (*Urochloa mosambicensis)* which did not recover from low plant populations or grew poorly, respectively. Growth habit varied considerably, ranging from low-growing types with dense canopies (*Stenotaphrum secondation* and *Brachiaria humidicola*) to tall and erect types (Mekong, T110). There was no significant damage due to insects or diseases.



a.



b.

Figure A2.37. Change in ground cover of legumes (a.) and grasses (b.) over two years of evaluation.

Covariate analysis of plot cover and herbage yield.

One of the difficulties of comparing mean biomass using quadrat cuts is that mean yield is inevitably influenced by ground cover. This is not a problem when cover is similar overall but can be problematic when cover ranges widely between cultivars or plots (poor establishment, weed competition). Covariate analyses can be undertaken to estimate plant dry biomass under a 'common' cover. Therefore, the inclusion of the covariate effectively increases the mean total dry matter yield for lines with low quadrat cover and reduces the mean for those with high quadrat cover. It should be noted this is only a tool to help understand the data set collected. Covariate analysis had little effect on grass yield rankings during the establishment phase of the experiment when there was considerable variation in sample cover, but rankings of some legumes were partially affected (Figure A2.38).

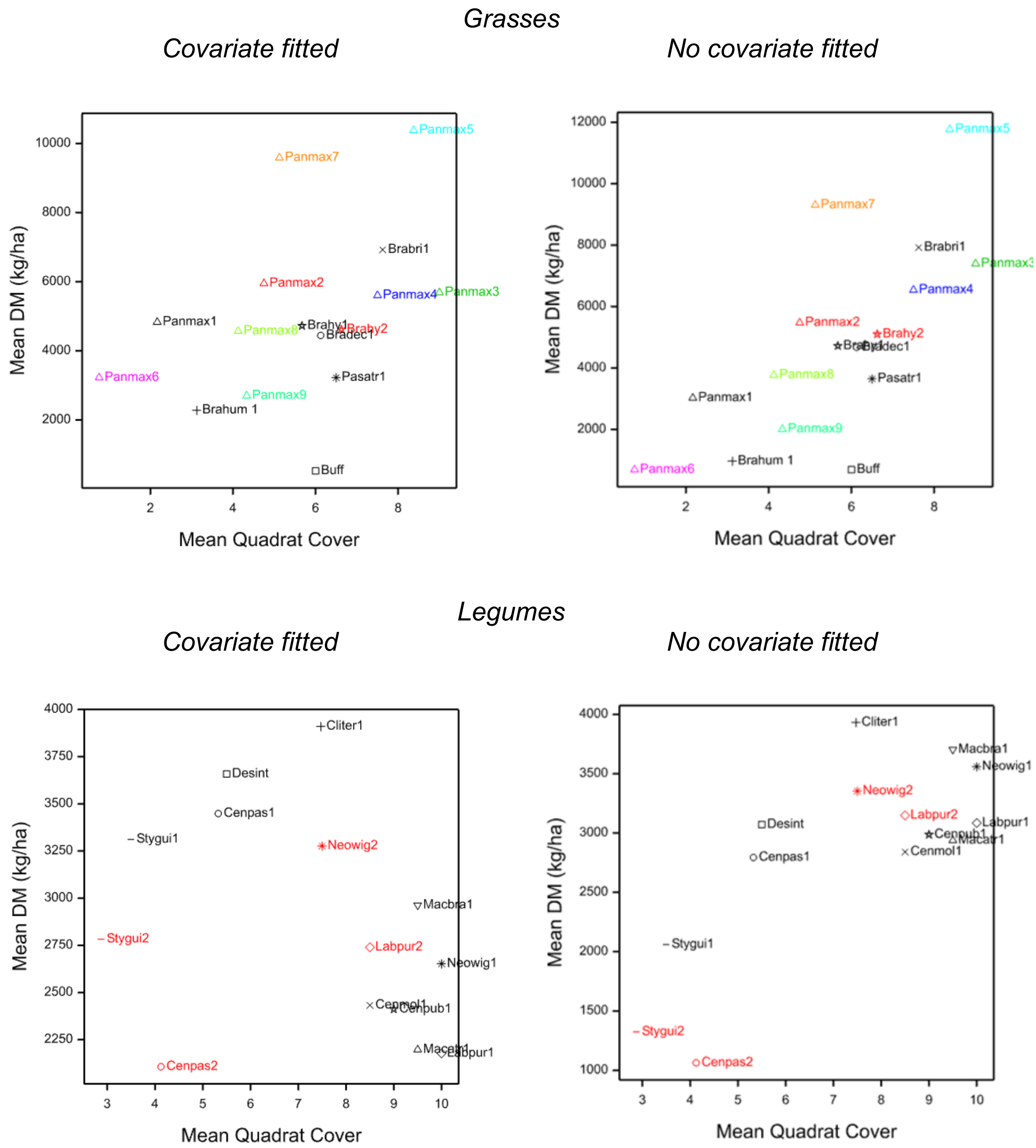


Figure A2.38. Covariate analysis of ground cover and dry matter yield of grasses and legumes during the establishment phase of the experiment.

Forage value

Plant samples collected during biomass harvesting are yet to be analysed. Feed value is broadly known for the species of grasses and legumes assessed through previous research and can be traced through tools such as the *Tropical Forages* selection tool (www.tropicalforages.info; Cook et al. 2005). The feed value of herbaceous legumes is typically high due to high levels of digestible energy and protein. Shrubby legumes, such as *Stylosanthes*, can decline considerably in quality as the proportion of stem increases over time. However, *Stylosanthes guianensis* is less woody than other *Stylosanthes* spp. typically used in drier environments and has been shown to have excellent feed value under regular cutting (Cox et al. 2012). Growth stage also significantly affects the feed value of grasses, with levels of digestible energy and protein declining as grasses accumulate biomass. The analysis of key indices of feed quality with harvested biomass should provide a guide of the comparative overall feed value of these grasses and legumes as they might be presented to cattle but only if access can be controlled.

Interpreting results of the experiment

The experiment was designed to rank the capacity of a range of grasses and legumes to produce herbage under defoliation compared to locally used types and provide an opportunity to mentor new research staff in pasture plant identification and selection. This approach has limitations, however the use of mechanical defoliation on grasses and legumes with a range of growth habits can create bias between lines as this does not perfectly imitate cattle grazing behaviour. Also, the experimental design used does not test the capacity for the grasses and legumes to persist and produce plant biomass within a mixed pasture, or test productivity under continuously or frequently grazed situations. Such an experiment would be beyond the resources of the project. Instead, the experiment has been used to identify grasses and legumes for further testing under conditions more typical of management in Vanuatu.

Communication and extension of results

The experiment was used to mentor a new forage agronomist at VARTC and other technical staff employed through the project. Skills were developed in plant identification, experimental design, agronomy, measuring herbage yield, data management, and presentation. The experiment also provided a practical resource for local agricultural college students and staff. With assistance from senior researchers, a poster paper was prepared by Jerine Naptapu and presented at the 2017 TropAg Conference, Brisbane. An information sheet on the experiment was also prepared as part of a series for use by extension officers.

Based on the results from this experiment, it was decided to include *Brachiaria brizantha* (Mekong), *Stylosanthes guianensis* (Nina and Temprano), *Neonotonia* (Tinaroo), and *Centrosema molle* (Cardillo) in a paddock-scale (6 ha) experiment to assess and demonstrate the effect of different stocking rates on legume persistence and pasture and animal productivity. This has now been established at VARTC.

Conclusions and recommendations

The experiment ranked newer lines of grasses and legumes against local comparators. A range of legumes regrew well after cutting and produced up to 10 T DM/year. The highest yielding legumes were *Stylosanthes guianensis*, *Desmodium intortum,* and *Neonotonia wightii*. These are all commercially available from Australia. High yields between 13 and 25 T DM/year were achieved by some grasses, including a range of *Panicum maximum, Brachiaria brizantha* and *Brachiaria* hybrids. These grasses out yielded the local comparators *Brachiaria decumbens* and *Stenotaphrum secondatum* over the experiment, mostly due to superior growth during the year after establishment. The *Brachiaria* cultivars are commercially available from Australia. The comparative performance of the evaluated grasses and legumes under grazing and management conditions practiced by smallholder cattle farmers in Vanuatu was not determined in this experiment but the findings do present some promising alternative grass and legume options that could be further trialled by farmers. It is recommended that any immediate follow-on research or extension focus on those lines that are commercially available from Australia.

Experiment 2. Small plot evaluation of legume persistence under shade

Prepared by: Kendrick Cox

Introduction

Grazing under coconut plantations represents a key resource for small-holder farmers in Vanuatu (MacFarlane and Shelton, 1982). *Stenotraphum secondatum* has been previously identified as the most appropriate grass for cattle production under coconut plantations due to its resilience under heavy grazing, tolerance of shade and 'tight' growth habit which can suppress weeds. However, its quality is low, and cattle productivity will be increased when legumes are included in the pasture. Hetero (*Desmodium heterophyllum*) persists well in buffalo pastures in shaded conditions but has moderate levels of production. Other legumes may be more productive. The objective of this small evaluation study was to determine the establishment and persistence of legumes within a buffalo grass base pasture under coconuts.

Materials and methods

A small (55 x 30 m) experimental site was established under mature coconuts on a calcareous sandy loam (pH_{water} = 8.1, $P_{Colwell}$ = 27 mg/kg, S_{MCP} = 42 mg/kg) at VARTC. The design was a replicated complete block with nine legumes and four replicates. The coconuts were spaced at 9 x 9 x 9 m and healthy and mature (older than 25 years). The buffalo grass was dense (full cover) and healthy, and *Centrosema pascuorum, Desmodium heterophyllum* and *Mimosa pudica* were the companion legumes. The site had previously been grazed intermittently.

Legumes were selected based on previous studies of legume growth under moderate to high levels of shade in Asia and the Pacific (Shelton and Stur, 1991) and good growth in the small plot assessment presented above (VARTC (2016-18). Two *Arachis* lines (*Arachis pintoi* and *A. repens*) growing in long-term plots at the Vanuatu Agriculture College were also included. *Leucaena* also represented a potentially useful forage type but, due to different management requirements, was grown in a separate experiment adjacent to that used for herbaceous legumes. Together, the legumes represent a range growing habits so will likely be suited to different management, low growing creeping types better for longer-term grazing (C), more erect types suited to intermittent grazing (E).

Single rows of *Clitoria ternatea*, *Stylosanthes guinanesis*, *Desmodium intortum*, *Neonotonia wightii*, *Arachi*s glabratta, *Centrosema molle,* and *Desmodium heterophyllum* (Hetero) were sown in a replicated block design between coconut trees (Figure A2.39). *Leucaena leucocephala* (Wondergraze) seedlings, ~0.5 to 1 m in height, were transplanted into a single row deep ripped by a tractor (0.5 m spacing between trees) or double rows (1 x 1 m spacings) and sown into shallow holes (0.2 m depth) dug by yam spades (Figure A2.40). Visual assessments of ground cover were conducted.

Planting material was sourced during late 2017. The legume seeds were sourced from Australia and tested (100 seeds, TP 35C, 12:12D) to confirm high viability and determine whether scarification was needed to overcome dormancy (Tinaroo). Vegetative planting material was sourced during the day of transplanting from plots at the VAC (*Arachis pintoi* and *A. repens*) or VARTC (*Desmodium heterophyllum*). The site was prepared by mowing the dense buffalo sward (tractor and slasher), ripping single rows with a ripper-tine towed by a tractor and spraying a band down each row with glyphosate at label rates. Each legume was sown on 2 February 2018 either by seed or runners (three nodes in the soil and two out) as described in Table A2.9. The soil over seeds was gently compacted by foot after sowing. A post and barbed wire fence was erected around the experiment area after planting to exclude cattle during establishment.

Figure A2.39. Establishment and persistence of a range of herbaceous legumes established under coconut trees at VARTC. (top) slashing and hand planting into ripped-lines; (row 2 left) source of stolons for establishing forage peanut; (row 2 right) vigorous *Arachis repens* growing into buffalo; (row 3 left) chlorotic *A. pintoi*; (row 3 right) *Desmodium intortum* (bottom left) *Desmodium heterophyllum* (bottom right) *Stylosanthes guianensis*.

Figure A2.40. Leucaena established under coconut trees at VARTC.

Table A2.9. Evaluation of the establishment and persistence of herbaceous legumes planted into established Buffalo grass pasture under shade at VARTC.

Legume	Cover	Vigour	Growth into buffalo	Comments
Arachis pintoi (Amarillo)	✓✓	✓	✓✓	some chlorotic leaves, strong flowering
Arachis repens	✓✓	✓✓	✓✓	strong flowering
Centrosema molle	✓	✓	✓	chlorotic leaves
Clitoria ternatea	✓✓	✓		chlorotic leaves, flowering
Desmodium intortum	✓✓	✓✓		some insect damage
Desmodium heterophyllum	✓	✓	✓✓	grew over buffalo
Neonotonia wightii	✓	✓✓		some insect damage
Stylosanthes guianensis	✓	✓		chlorotic leaves

Simple observations were used to rank legumes for persistence and growth because the workload of the project team was high during 2018. A photographic record was completed. The plots were initially not grazed but slashed with a tractor occasionally to reduce bulk (attempts to allow cattle access to graze the plots were unsuccessful because of the amount of alternative feed available. It was decided to remove fences during 2019 and allow free access by cattle to the plots.

Results and discussion

Low rainfall in the month after planting the herbaceous legumes caused stress to the vegetatively propagated legumes and delayed establishment from seeds, but ~800 mm of rainfall during March and April ensured vigorous plant establishment and growth. Winter (May-August) rainfall was less than long term values and did not exceed 100 mm/month. Rainfall thereafter was higher than for long-term records and exceeded 2000 mm for the 2018-19 wet season. The plants did not exhibit obvious signs of water stress.

Visual assessments suggest that *Neonotonia wightii*, Desmodium *intortum*, *Arachis repens,* and *Leucaena leucocephala* all persisted well and grew vigorously under coconut trees of this age and on this soil type. The low-growing *Arachis* and *Desmodium heterophyllum* lines grew into buffalo grass thatch, indicating they may persist better under grazing, particularly under heavy grazing. *Arachis* spp and *Leucaena* spp are recommended for further testing at a larger scale and under grazing scenario's due to their more likely resilience under grazing.

Conclusions and recommendations

Arachis spp, particularly *A. repens*, is recommended for plantation under shaded environments and is likely to persist well under heavy grazing. Leucaena is also recommended under certain circumstances where segregation of classes of cattle is possible. Whilst twinning legumes such as *Neonotonia wightii*, *Desmodium intortum,* and *Stylosanthes guianensis* established well under shade their persistence under grazing requires evaluation.

Experiment 3. Leucaena biomass production in Vanuatu

Prepared by: Simon Quigley

Introduction

Leucaena (*Leucaena leucocephala*) is a long-lived tree legume suited to the dry tropics. It produces high protein cattle feed throughout the year when managed well, promoting higher growth rates under grazing (e.g. QLD, Australia) and cut-and-carry (e.g. Indonesia) systems. The main leucaena lines planted by cattle producers in Australia are Tarramba and Wondergraze, with the newer Redlands variety recently released. A local naturalised leucaena (kasis) is commonly found across Vanautu but is rarely utilised as a managed feed resource. The current activity was initiated to demonstrate the establishment and management of Tarramba and Wondergraze leucaena varieties from Australia and to compare these against the naturalised kasis, however Redlands was not available for export and testing due to limited supply in Australia.

Materials and methods

The activity was incorporated into the forage evaluation trial conducted at VARTC (15°26'59.65"S; 167°11'34.74"E). Seeds of each species of leucaena (Tarramba, Wondergraze, Kasis) were hand scarified and planted in poly bags without inoculation. After germination, seedlings were maintained in poly bags until approximately 6 months of age before transplanting into (two) rows that were ripped to 0.5 m depth. Each row was divided in half, giving a total of four blocks. Ten seedlings from each variety were transplanted into rows at 1 m spacings. No fertiliser or irrigation was applied to seedlings after transplantation.

Approximately 12 months after transplantation five seedlings of each species within each block were cut to 0.5 or 1.0 m in height with a large hand pruner (Figure A2.41). Bioharvests were conducted every 90 to 100 days thereafter (six bioharvests were conducted between July-2018 to November-2019). Total biomass, edible leaf and inedible stem weights and the number of pods were recorded for each tree. Samples of edible leaf and inedible stem from each cutting height, for each species, within each block, were dried to a constant weight at 60°C and total dry matter production was determined.

a. b.

Figure A2.41. Initial cutting of leucaena in March-2018 (a.) and first biomass harvest in July-2018 (b.).

Results and discussion

All seedlings established readily after transplantation. Leaf and stem biomass production was higher when trees were cut at 1.0 m height, regardless of species (Table A2.10), although the proportion of leaf to stem was unaffected by species and cutting height. Trees cut at 1.0 m produced more pods with Kasis producing more pods than Tarramba and Wondergraze at both cutting heights, however the number of pods from all trees was quantitatively small at both heights.

Table A2.10. Biomass production and number of pods produced per tree for Tarramba, Wondergraze and Kasis leucaena at different cutting heights.

Species	Cutting height	Leaf	Stem	Total	Proportion of DM biomass, %		Pods
	m	kg DM/tree	kg DM/tree	kg DM/tree	Leaf	Stem	Number/tree
Tarramba	1.0	0.39	0.67	1.16	46.0	54.0	0.30
Wondergraze	1.0	0.62	0.85	1.62	49.3	50.7	2.46
Kasis	1.0	0.32	0.56	0.96	46.9	53.1	7.78
Tarramba	0.5	0.35	0.57	1.01	47.4	52.6	0.00
Wondergraze	0.5	0.46	0.61	1.19	49.9	50.1	0.56
Kasis	0.5	0.29	0.64	1.01	44.2	55.8	1.44

Conclusions and recommendations

Preliminary results would indicate the optimum species and cutting height combination to maximise biomass production and minimise seed set is the establishment of Wondergraze with grazing or harvesting regrowth at intervals of less than every 90 days to avoid the risk of seed production and self-establishment of weedy seedlings and trees. Further research is required to determine the optimum management of leucaena under grazing in Vanuatu.

Experiment 4. Effect of stocking rate and spelling on liveweight gain and persistence of legumes in a Mekong grass based pasture in Vanuatu

Prepared by: Kendrick Cox and Simon Quigley

Introduction

On-station evaluation research at VARTC was used to identify new grasses and legumes lines suitable to the wet tropical environment of Santo, Vanuatu, and compare these against productivity of older cultivars. At a producer field day at the VARTC evaluation site, local farmers showed interest in these new grass and legume lines but asked pertinent questions regarding likely productivity and appropriate grazing management and stocking rates. Recommendations for producers should include some indication of relative liveweight production and persistence of legumes under different grazing management under local conditions. To generate local evidence based recommendations to assist smallholder farmers with their pasture improvement and pasture management decisions, a small demonstration trial was established at the VARTC to determine the persistence of legumes and the growth rates of steers grazing new forage lines under different grazing management strategies.

One pasture grass (Mekong *Brachiaria brizantha*) and three species of perennial pasture legumes (Cardillo *Centrosema molle,* Tinaroo *Neonotonia wightii,* and Nina and Temprano *Stylosanthes guianensis*) were selected for the grazing experiment based on:

- performance in the small-plot experiment (2016-18); Mekong, Tinaroo, Nina, and Temprano yielded well (Cardillo had moderate yields) and all regrew well after cutting, and
- varying capacity to persist under heavy or regular grazing once productive; *Neonotonia wightii* has declined in Vanuatu pastures (McFarlane and Shelton, 1986) and *Stylosanthes guianensis* can decline under regular grazing (Cook et al., 2005), whereas *Centrosema molle* has proven to be persistent under regular heavy grazing in the wet tropical in the Australian wet tropics (Lowe et al., 1998).

Materials and methods

A 6 ha experimental site was established at VARTC, Santo (15°28'44.66"S; 167°11'23.93"E) between July-2017 to May-2018. The site was immediately adjacent to the small plot grass and legume experiment (on-station research, Experiment 1). The site was cultivated and sprayed twice with post-emergence herbicide. Seeds were purchased from Australian seed companies and tested for viability to adjust sowing rates (the sowing rate of the Mekong seeds was increased because of relatively low viability). The entire site was divided into 800 m^2 sections and the seeds broadcast at the following rates: Mekong 13 kg coated seeds/ha, Cardillo 6 kg/ha, Tinaroo 6 kg/ha, and Nina, and Temprano 2 kg/ha each (Figure A2.42). The seeds were covered with soil using towed steel pickets and the surface gently compacted into the soil by quadbikes borrowed for the purpose. No fertiliser was applied. The site was then fenced into six 1 ha paddocks (replicates) with a shared water trough between adjacent paddocks (Figure A2.43).

Figure A2.42. Preparation and establishment of the experimental site.

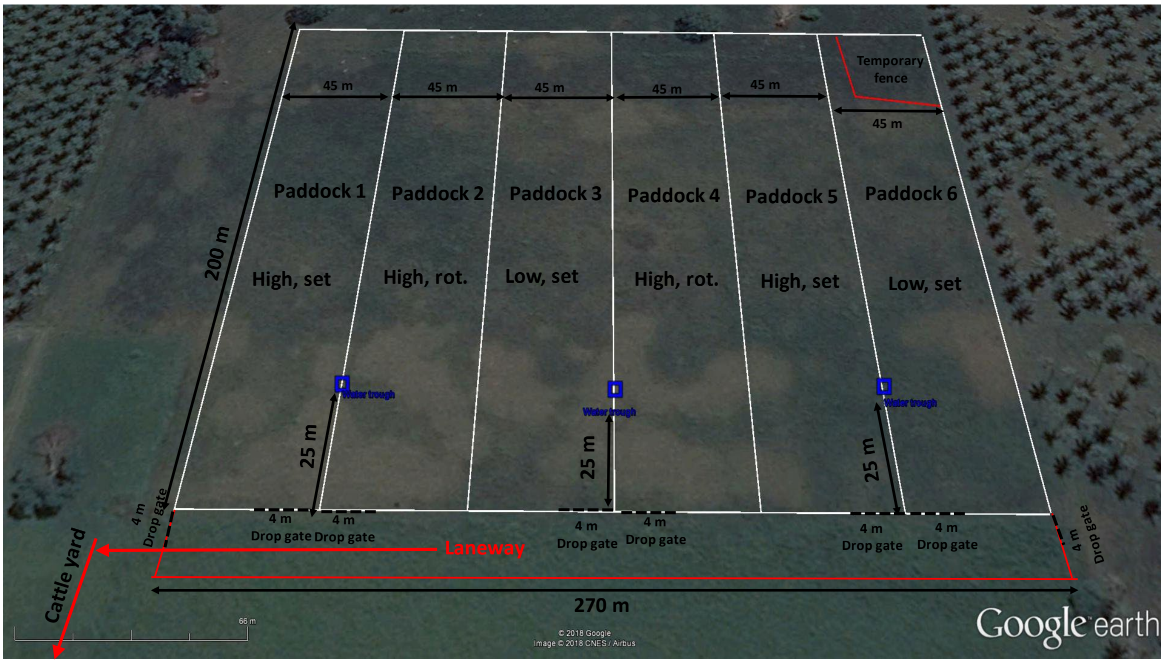


Figure A2.43. Experimental layout. (see below for treatment details).

On 24-October-2018, VARTC local steers (n=30; 218 ± 50 kg liveweight; mean ± SD), were treated for internal and external parasites (Cydectin; Bayer Animal Health), weighed and ranked on liveweight and blocked as either Light or Heavy steers. Within each block, steers were randomly allocated to two low set stocking rate replicates (LS; n=3/replicate), two high set stocking rate replicates (HS; n=6/replicate), and one high rotational stocking rate treatment (HR; n=12). The LS and HS replicates remained in the same paddock for the duration of the experiment, whilst the HR replicate rotated between two paddocks every 30 days (i.e. a 30-day grazing followed by a 30-day recovery cycle). This resulted in the mean stocking rates of 1.4 (LS) and 2.9 (HS and HR) animal units/ha (1 animal unit = 450 kg steer equivalent). In June-2019, after 8 months of grazing, an adjustment was made by reducing the stocking rates of all replicates by one-third to sustain pastures which were becoming over-grazed. The revised stocking rates at this time were 1.5 (LS) and 2.7 (HS and HR) animal units/ha. The experiment continued for 4 months until October-2019 when the first cohort of steers were removed from the site to allow pastures to recover over the wet season before the introduction of a new cohort of weaner steers in 2020. It was proposed the experiment continue with replacement weaner steer cohorts at approximately every 12 months and animal and pasture assessments be continued as described below (Figure A2.44).

Pasture assessments were conducted immediately prior to commencement of the experiment (October-2018), prior to stocking rate adjustments (June-2019), and at the end of the first 12 month grazing phase (October-2019). Plant frequency was measured at 20 sampling points evenly distributed throughout each paddock. Each measurement was conducted within a randomly placed 0.7 x 0.7 m quadrat. A visual rating of the proportion ground cover of each of the four sown pasture grasses or ‘other plants’ (value up to 10, 0 = none and 10 = whole quadrat area). Biomass cuts were completed at four (quadrats 3, 8, 13, and 18) in each paddock. Wet and dry weights were measured for each component and estimates of herbage yield and percentage dry matter calculated. Extremely low pasture yields prompted changes to grazing treatments, i.e. when it was considered there was inadequate feed to sustain the animals.

Steers were moved to the stockyards every 30 days and liveweight recorded after a 12-hour feed and water curfew. Faecal samples were collected from each replicate of steers each month and analysed by F.NIRS to predict the crude protein and digestibility content and the proportion of non-grass in the diet consumed by the cattle, and for FECs to determine internal parasite burdens.

Figure A2.44. Pasture measurements prior to the introduction of cattle in October-2018.

Results and discussion

Seasonal conditions

Rainfall over the first 12 months of the experiment was 2567 mm which was similar to long-term means. After a dry November and a very wet December-2018, the rainfall pattern was typical of southeast Santo for the remainder of the experimental period, with above 50 mm rainfall measured across all months of the year (Figure A2.45).

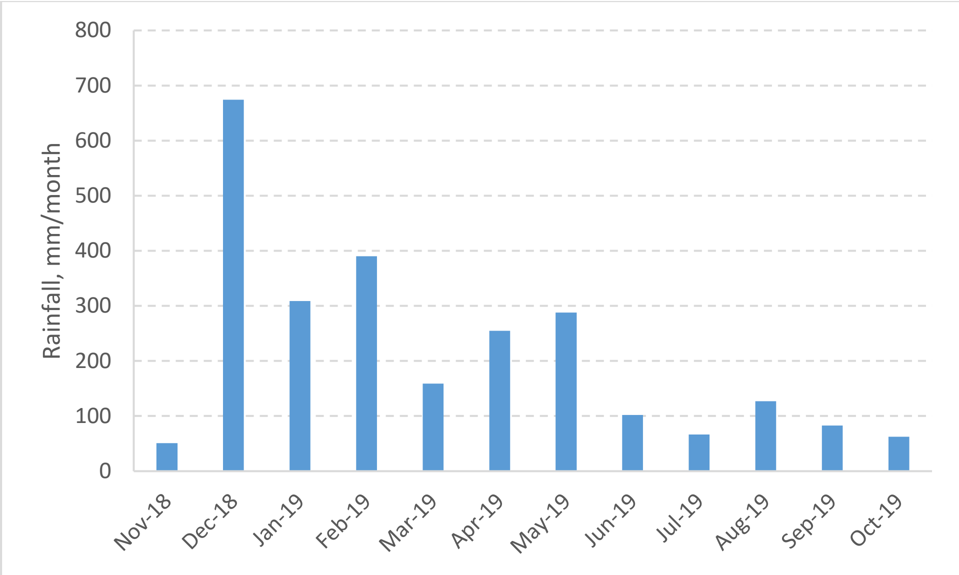


Figure A2.45. Monthly rainfall at VARTC during the first year of the grazing experiment.

Pasture assessments

Satisfactory (>90%) pasture cover was achieved before the cattle were introduced in October-2018. The only exception was an area on the end of a LS stock replicate paddock (6) where establishment was poor. Mekong grass (30-38%) and the sown legumes were all well represented in pasture (Figure A2.46). The legumes varied in initial cover: Tinaroo glycine was relatively even at ~20%, whereas Cardillo centro and Nina stylo varied between 9 and 23% between paddock replicates. Other plants were present in the pasture (~8-16%, depending on treatment) and included pico (*Solanum torvum*), sensitive weed (*Mimosa pudica*), and grasses (*Eleusine indica*, *Brachiaria decumbens*). Pasture herbage yield presented to cattle ranged from ~3.0 to 4.5 T DM/ha, with values highest in the paddocks allocated to the High-set stocked treatment (Figure A2.47). Mekong grass represented 54-73% of pasture herbage on offer, followed by Tinaroo (14-25%), and Nina (10-20%). Cardillo herbage yields were low (<3%).

The three grazing treatments resulted in changes to cover and biomass of the pasture components. The amount of feed available after wet season grazing (October – June) ranged from 0.9 (HS stocked) to 1.4 (LS stocked) T DM/ha. There was a reduction in the cover of the legumes, and an increase in grass (Mekong) cover. The one exception was for Tinaroo glycine in the LS stock treatment which maintained cover and increased biomass.

Differences between the grazing treatments were greater over the dry season (June to October). Total herbage yields on offer increased to over 4 T/ha in the LS stocked treatments but were only 1 T/ha at the higher stocking rate. There was 3.3 T DM/ha on offer in the HR treatment (2.0 T DM/ha in the paddock being grazed and 3.7 T DM/ha in the paddock not being grazed). The HS stocked treatment resulted in a decline in the cover of the all pasture components (grass and legumes) and a significant increase in weeds, whereas Mekong and Tinaroo levels were maintained or increased (Tinaroo) in the LS stocked treatments and the proportion of weeds declined. The HR treatment maintained grass cover, but there was a decline in legume content and a slight increase in weed cover.

Overall, by October-2019 the LS stocked treatment was considered understocked whereas grazing pressure in the HS stocked treatment was damaging pasture. It was decided to remove cattle from the high stocking rate treatment as it was considered there was inadequate feed on offer. The HR stocking treatment appeared to be producing similar yields to the LS stocked treatment but weed content may have increased under this grazing regime. Tinaroo glycine was the best performing legume to date, with Cardillo centro having low cover and biomass from the onset of grazing and Nina stylo declining in all treatments.

There were some early indications that Cardillo, may be increasing cover in the HS stocked treatment, having tripled in herbage yield (albeit from a low base).

Steers

The average daily gain of steers under the LS (0.46 kg/steer) was higher than that of HS and HR (0.36 and 0.24 kg/steer) steers for the first phase of the experiment (October-2018 to June-2019). After the adjustments to stocking rates (June-2019) the average daily gain of steers under the LS and HR treatments increased significantly (0.86 and 0.72 kg/steer), whilst liveweight gain of steers under the HR treatment remained the same as the first phase (0.40 kg/steer.day). Across the total experimental period, steers under the LS treatment had higher average daily gain (0.53 kg/steer) than steers under the HR and HS treatments which were not different (0.34 and 0.32 kg/steer). Cumulative liveweight gain for the LS, HR, and HS treatments were 225, 165, and 145 kg/steer or 450, 660, and 580 kg liveweight/ha (based on the number of steers/ha after June-2019) (Figure A2.48). An annual liveweight production of 235 kg/steer.year (0.6 kg/day) is required to reach the top carcass weight (270 kg CWT; 500 kg LWT) of the price grid at the commercial abattoirs at two years of age.

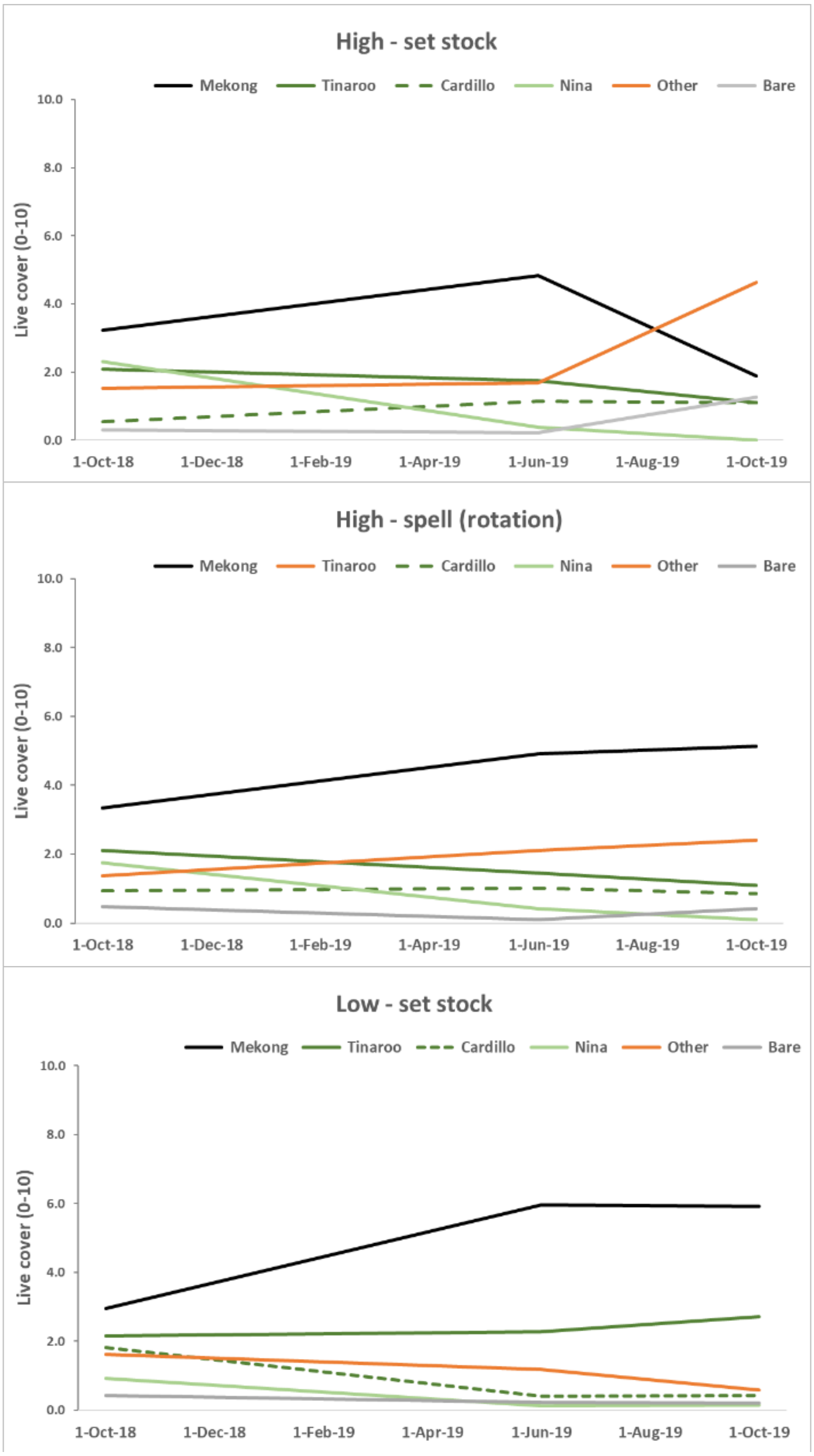


Figure A2.46. The effect of grazing regimen on ground cover. Visual ratings of live ground cover were conducted in 20 0.5 m^2 quadrats per paddock (40 per treatment).

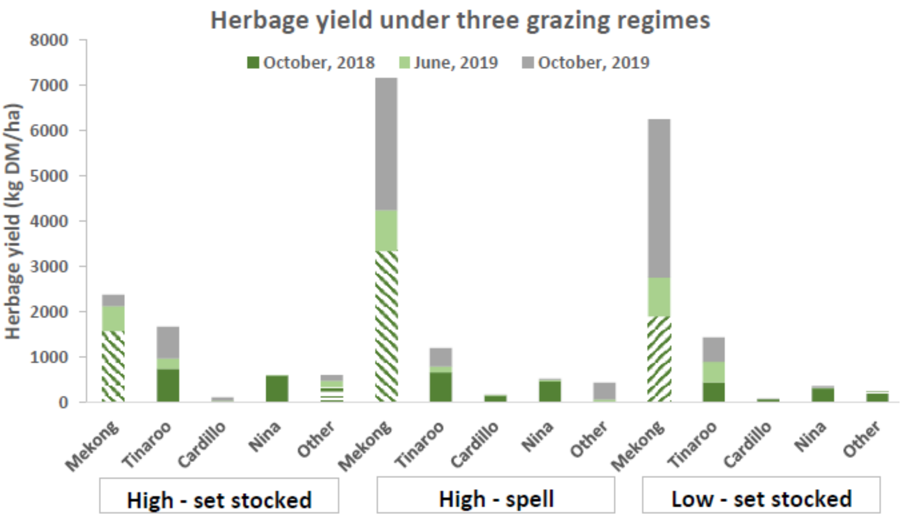
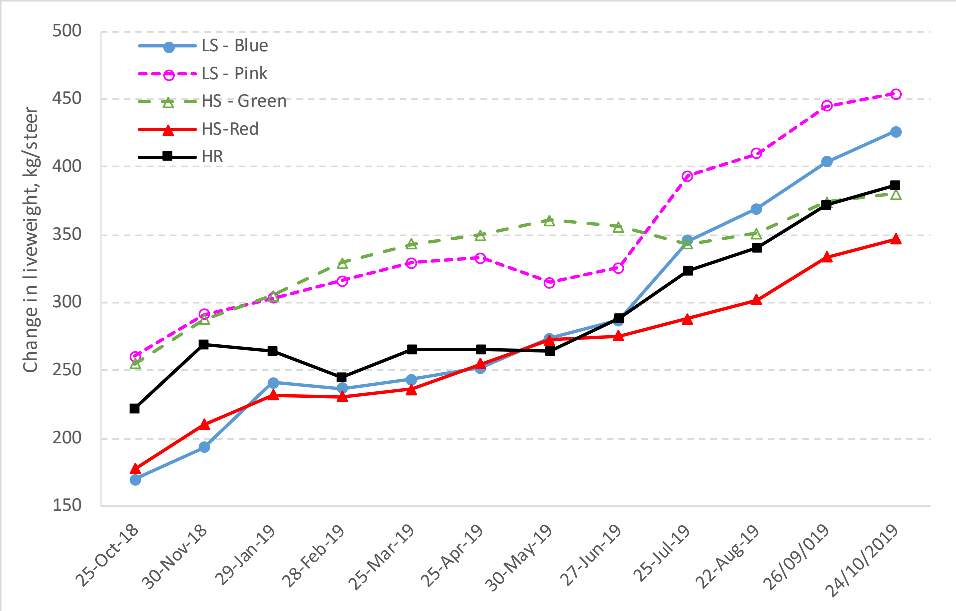


Figure A2.47. The effect of grazing regimen on dried herbage yield.



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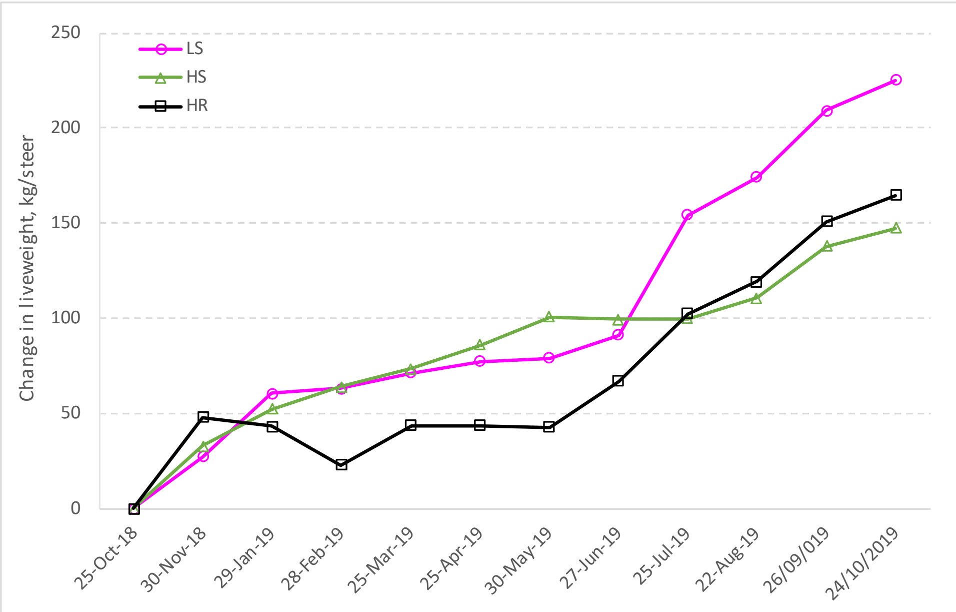
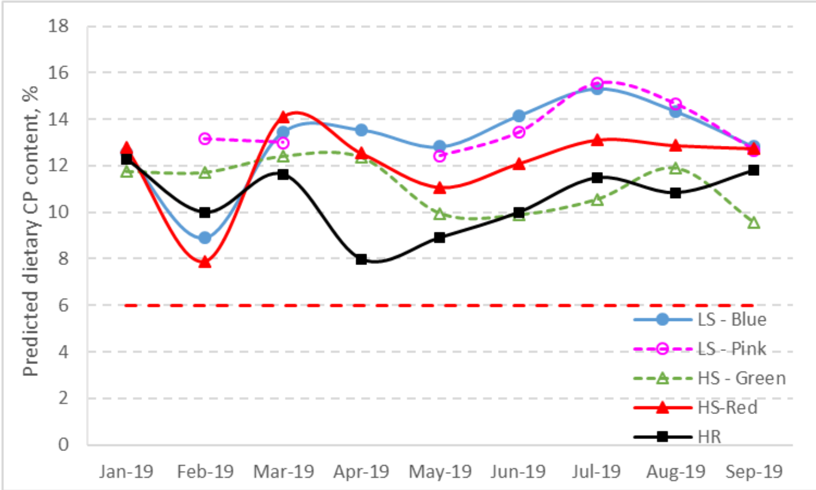


b.

Figure A2.48. Change in liveweight (a.) and cumulative liveweight change of steers grazing Mekong pastures at low (LS) and high (HS) set stocking rates and a high (HR) stocking rate with pasture spelling.

Predictions of diet quality would suggest that crude protein and ME are not limiting in these pastures throughout the year, and grazing management had no effect on the nutritional value of the diets consumed by the steers (Figure A2.49). The crude protein and ME content were as expected for high quality tropical pastures when rainfall is not limiting. The predicted proportion of non-grass (i.e. legume) consumed by the cattle was lower than that determined through pasture assessments and lower than might be expected given the high legume content measured at the start of the grazing period (~30%) which was only 12 months in duration. The prediction of non-grass in the diet did not follow a declining trend across the period, which may have been expected if cattle had preferentially selected non-grass. This may simply be due to the very high amount of grass biomass present in the paddock replicates. Alternatively, this may indicate an issue with the sampling technique or the prediction equation itself rather than reflect the actual diet consumed by the cattle. The calibration equations used in these predictions were developed using diets, including non-grass species that are relevant to cattle in northern Australia.



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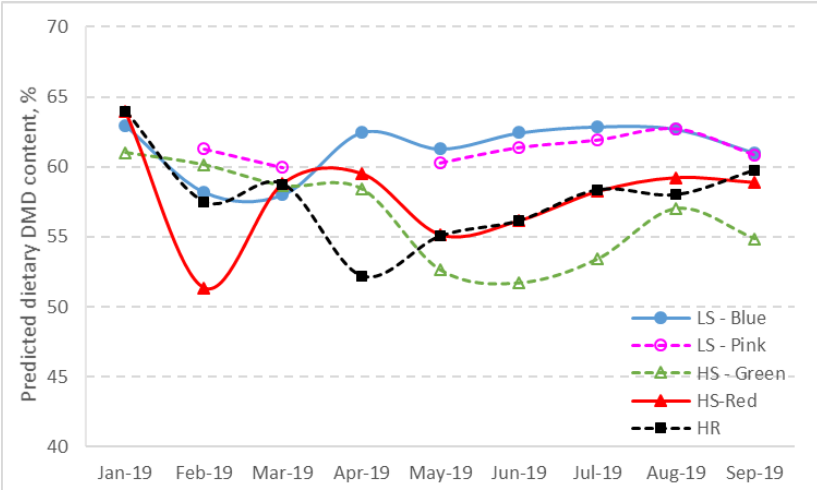

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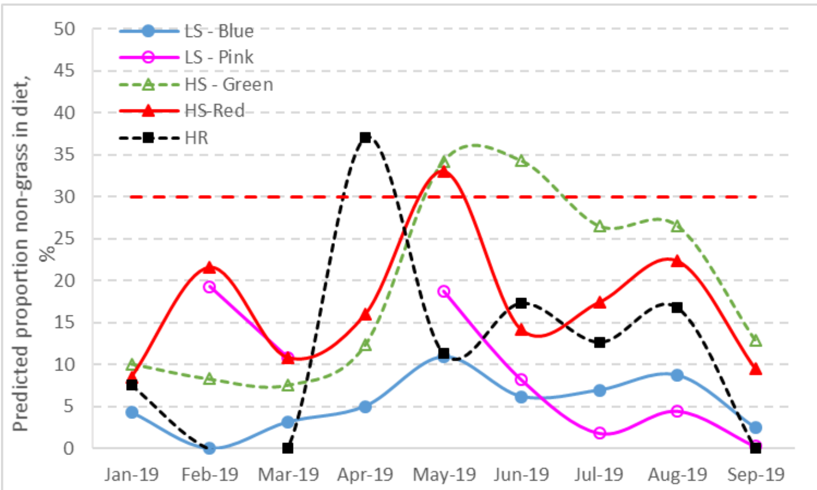


c.

Figure A2.49. Faecal NIRS prediction of the crude protein (a.), dry matter digestibility (b.), and the proportion of non-grass (c.) of the diet consumed by steers at low set (LS), high set (HS), and high rotational (HR) stocking rates at VARTC during the experimental period (Oct-2018 to Oct-2019). Red-dashed lines indicate the minimum crude protein and the targeted proportion of legumes in the diet of cattle; each line in legend indicates an experimental paddock/replicate.

The FECs were high (1900 epg) at the commencement of the experiment prior to preventative treatment but remained relatively low (<200 epg) for the majority of the months across all paddock replicates, indicating grazing management had no effect on internal parasites within the pastures and grazing systems tested within this experiment. A high load was detected in a single paddock replicate (LS, 950 epg) in September-2019 but had returned to 0 epg in October-2019. The reason for this spike in FECs is unknown but is of little concern given the apparently transient nature.

Conclusions and recommendations

It is possible to establish a medium-scale (6 ha) grass-legume improved pasture grazing area with minimal inputs in Vanuatu. Preliminary results suggest that pasture yield, legume persistence, and pasture quality were all maintained under lower stocking rates or higher stocking rates with regular spelling, with highest liveweight production also measured under these conditions. Based on the initial 12 month grazing period, a stocking rate of 2.7 AU/ha (or higher) is unlikely to be sustainable for this pasture mix from both the perspective of the pasture and annual liveweight production unless pasture spelling is part of the management strategy.

Experiment 5. Response of growing steers to copra meal supplementation in the wet and dry season on Santo, Vanuatu

Prepared by: Simon Quigley

Introduction

The crude protein content of tropical grasses often declines in the dry season, resulting in low liveweight gain of cattle consuming these pastures. The provision of a protein supplement often results in an increase in intake of the available pasture and an increase in liveweight gain over this period. This decline in crude protein content and hence liveweight gain of cattle is likely to be more pronounced in the dry tropics (of northern Australia) than in the wet tropics of Vanuatu. In contrast, lower liveweight gain may be reported in the wet season in the wet tropics, where ME intake from pastures decline due to increased water content of pastures and changes in grazing behaviour. The supply of concentrated ME in the form of a supplement during the wet season may increase growth rates of cattle consuming high water content pastures in extreme wet and humid conditions.

Copra meal is the only by-product in Vanuatu available at a scale that would allow its use as a cattle supplement on a wide scale. Copra meal is a mid-range protein source (200 to 240 g CP/kg DM) that has a variable lipid content depending on the method used to extract coconut oil (solvent <50 g lipid/kg DM; mechanical <100 g lipid/kg DM). The higher lipid content of copra meal compared with other protein supplements may result in beneficially high ME content (12.8 MJ/kg DM) and potentially lower rumen degradability and higher bypass proteins, but also may contribute to rancidity under prolonged storage. This rancidity may contribute to issues with palatability, which may explain some of the variable intakes recorded in the literature. Copra meal is currently produced by COPSL on Santo with a local purchase price of 1000 vatu/25 kg bag (AU$550/T of dry matter).

McLennan (2004) demonstrated a curvilinear increase in liveweight gain (from -0.1 to 0.6 kg/day) of *Bos indicus* steers in response to increasing copra meal supplementation (over the range of 0 to 10 g supplement/kg LW.day) when fed a low protein (50 g CP/kg DM) Rhodes grass hay. The response to copra meal (242 g CP, 498 NDF, 73 g EE/kg DM) was the same as the response to cottonseed meal (428 g CP, 228 g NDF, 19 g EE/kg DM). Similar responses to cottonseed meal and copra meal were reported for growing steers fed dry season pastures (Gulbransen et al., 1990), further demonstrating the high feed value of copra meal, despite the lower CP content than some other protein sources. In the studies of McLennan (2004) and Gulbransen et al. (1990) almost complete intakes of copra meal were achieved. In contrast, Ehrlich et al. (1990) and Silva (2017) both reported lower than expected intakes of copra meal (~3 to 4 g DM/kg liveweight.day) for dairy cows grazing irrigated pangola grass and weaned Brahman heifers fed dry season native pastures suggesting variable issues with the palatability of copra meal.

Despite the local availability of copra meal in Vanuatu no data is currently available on the intake and response of cattle to copra meal supplementation. The objective of this experiment was to confirm the acceptability of copra meal to cattle in Vanuatu and the effect on liveweight gain when offered as a supplement in the wet and dry season.

Materials and methods

An experimental site was established at the Monbiftek farm, Luganville (15°28'44.66"S; 167°11'23.93"E) in a single 6 ha paddock based on buffalo grass with a large burden of weeds (*Mimosa*, *Solanum*, *Senna*, *Acacia* spp) with no drinking water available.

In October-2018, Local (n=16) steers were purchased from a nearby large holder and relocated to Monbiftek farm. Steers were treated for internal and external parasites with Cydectin Pour-on (5 mg moxidectin/mL; Bayer HealthCare, Animal Health Division, USA) at the rate of 1 mL/10 kg liveweight, ear tagged, and introduced to regular handling and copra meal at a mob based level.

On 3-November-2018, the start of wet season treatment period, the steers were weighed (n=16; 216 ± 32 kg liveweight; mean ± SD), ranked on liveweight, and allocated to copra meal supplementation (n=6) or unsupplemented (n=10) treatments. On 3-May-2019, the start of the dry season treatment period, steers that were unsupplemented in the wet season were weighed, ranked on liveweight and allocated to copra meal supplementation (n=5) or unsupplemented (n=5) treatments until the experiment was concluded on 04-October-2019. The wet and dry season treatment periods were both 154 days in duration. One steer did not consume any copra meal during the dry season and was removed from the treatment group and considered an unsupplemented steer in both seasons. Steers supplemented in the wet season received no supplement in the dry season (n=6). This resulted in three treatments,

1. copra meal supplementation in the wet season/no supplementation in the dry season (Copra-NIL; n=6)
2. no supplementation in the wet season/copra meal supplementation in the dry season (NIL-Copra; n=4)
3. no supplementation in the wet season, no supplementation in the dry season (NIL-NIL; n=6)

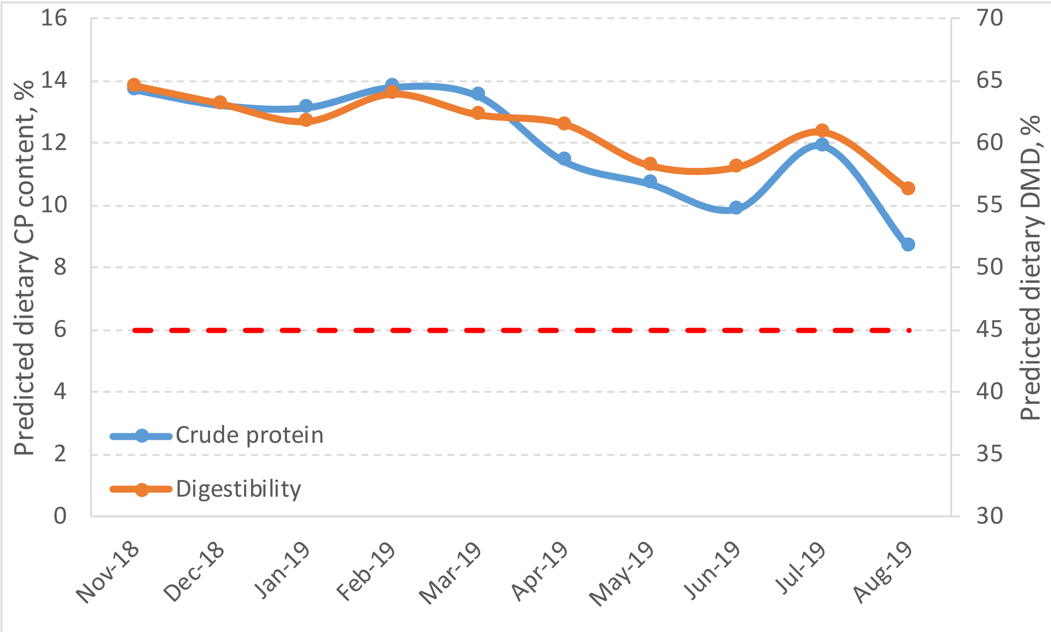
During both the wet and dry season periods, steers allocated to the copra meal supplement were moved to the cattle yard (located within the paddock) on Monday, Tuesday, Wednesday, and Friday each week and placed in individual feeding stalls. Each steer was offered the equivalent of 5 g copra meal DM/kg LW.day distributed equally across the four feeding events each week. The copra meal offered was adjusted after the weighing of steers every 14 days. Steers remained in stalls from approximately 0800 to 1400 each day and were then released to the paddock. Daily copra meal intake was determined from the difference between amounts offered and refused averaged across a 14-day period. All steers continued to graze as a single mob in the same paddock throughout the experiment. Copra meal was purchased from COPSL in batches that were stored on-site in a large shipping container for 3 to 4 months before additional batches were purchased. Samples were collected from each batch and tested at The University of Queensland (900 g OM, 204 g CP, 1.1 g Ca, 5.7 g P, 23.7 g K and 2.8 g Mg/kg DM).

All steers were weighed every 14 days with faecal samples collected from unsupplemented steers each month for F.NIRS prediction of diet quality and internal parasites (for supplemented and unsupplemented steers). The samples were collected from individual steers and bulked within treatments.

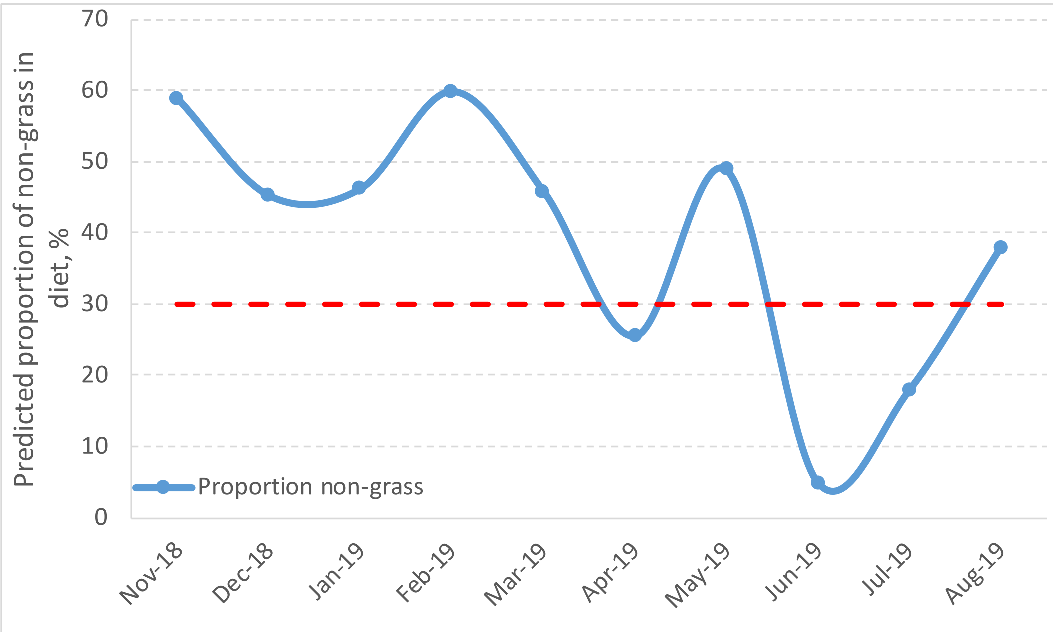
Results and discussion

Intake of copra meal was lower than expected during both the wet season (2.8 g (as fed)/kg LW.day) and dry season (2.4 g (as fed)/kg LW.day). Attempts to increase intake were made by the inclusion of small amounts of sugar and salt with the copra meal but these had no impact on intake. Copra meal intake did tend to increase throughout the wet season (< 1 g/kg LW.day December-2018 and January-2019 to 3.6 g/kg LW.day in April-2019) and declined in the latter part of the dry season period (2.8 g/kg LW.day from May to August-2019 and 1.7 g/kg LW.day mid-August to early October-2019).

Regardless of the quantitatively small changes throughout the year, intakes were low (<4 g/kg LW.day) compared to other studies where liveweight gain responses of growing steers to copra meal supplementation have typically been reported (McLennan, 2004; Gulbransen et al., 1990). It is important to note these studies where a higher intake of copra meal and greater liveweight responses were reported were conducted in situations when the crude protein content of the basal diet was low (<50 g CP/kg DM). The quality of the diet consumed by unsupplemented steers in the current experiment never fell below 85 g CP/kg DM or below 55% dry matter digestibility (Figure A2.50), suggesting that steers had access to forages that were not limited in protein or energy content at any stage. The predicted non-grass proportion in the consumed diet averaged 39% across the entire period and approached 50% in the majority of months, suggesting local legumes and weeds were forming a large portion of the diet consumed by the steers. Given the high crude protein and ME content of the basal diet it is unsurprising that intake of the copra meal was lower than anticipated. Whilst the copra meal did not appear rancid after prolonged storage it is possible that this also affected palatability and intake, however it is noted that intakes were low from the very start of the experiment when fresh copra meal was used.



a.



b.

Figure A2.50. Faecal NIRS prediction of the crude protein and dry matter digestibility (a.) and the proportion of non-grass (b.) of the basal diet consumed by unsupplemented steers at Monbiftek during the experimental period (Nov-2018 to Aug-2019). Red-dashed lines indicate the minimum crude protein (a.) and the targeted proportion of legumes (b.) in the diet of cattle.

Steers supplemented with copra meal during the wet season grew at 0.48 kg/day compared with 0.34 kg/day for unsupplemented steers over the same period. This equated to an additional 24 kg of liveweight/steer over the 154-day wet season treatment period (56 vs 79 kg liveweight gained/steer). Steers supplemented with copra meal during the dry season grew at 0.43 kg/day compared to unsupplemented steers that grew at 0.40 kg/day (03-May to 04-Oct-2019). If growth rates are examined until copra meal intakes declined (03-May to 23-Aug-2019) then the supplemented steers grew at 0.43 kg/day compared with 0.37 kg/day for unsupplemented steers. The response to copra meal during this period equated to a 4 kg difference in liveweight between supplemented and unsupplemented steers (53 vs 49 kg over 154 days) with most of the benefits from wet season supplementation eroded over the ensuing dry season (Figure A2.51).

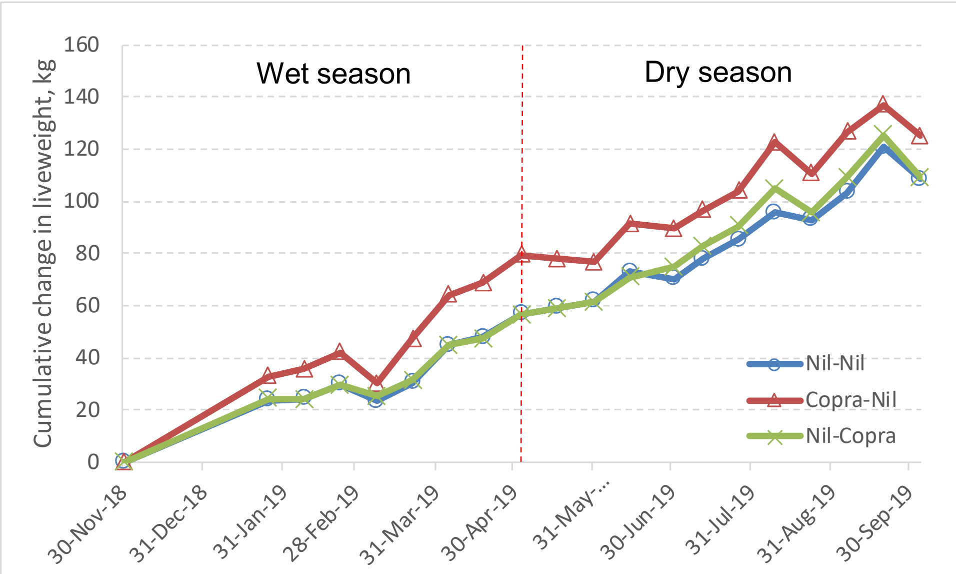


Figure A2.51. Cumulative change in liveweight of steers offered copra meal supplements in the wet or dry season or unsupplemented across both seasonal periods.

Apart from a large spike in FECs during Febraury-2020 (~2000 eggs per gram for both supplemented and unsupplemented steers) numbers remained between 0 and 250 epg for all other months with no differences between supplemented and unsupplemented steers in any month. Given the generally low counts it is unsurprising that supplementation had no effect on FECs, either directly or indirectly as a result of any changes in grazing behaviour.

Profitability was calculated using assumptions from the current experiment of a mean steer liveweight of 250 kg, growth rate of 0.48 kg/day and 0.43 kg/day (wet and dry season respectively)' copra meal intake of 0.75 kg/day (i.e. 3 g/kg LW.day), cost of copra meal of 40 vatu/kg, and a value of 100 vatu/kg liveweight. The profit above feed cost for wet and dry season supplementation would be 18 and 10 vatu/steer day respectively. This calculated value takes no account of additional costs such as transport, storage, and feeding infrastructure and labour. A partial budget analysis is likely to reveal little profitability in copra meal supplementation of cattle in Vanuatu, particularly when the forage base is not limiting in CP or ME, as was the case in the current experiment.

Conclusions and recommendations

Intakes of copra meal and subsequent growth rates of steers in this experiment were lower than anticipated. This is likely due to the high-quality basal diet, and potentially behavioural changes associated with the frequent moving of animals to stalls for supplementation. In addition, supplementation had no effect on the incidence of internal parasite burdens, which were low. The limited productivity benefits, low profit margins, and fairly high logistical requirements to source, store, and feed copra meal suggests that this regime is probably not recommended for the majority of smallholder cattle farmers with small cattle herds. Maintaining a high protein and high ME forage base through appropriate stocking rates and grazing management is likely to be more practical and beneficial in the wet tropics where protein content of the forage base is rarely deficient for cattle over 240 kg liveweight.

Experiment 6. Response of growing heifers to the availability of drinking water in the wet and dry season

Prepared by: Simon Quigley

Introduction

Only 10 (VNSO, 2007) to 20% (NZ MFAT, 2017) of smallholder cattle farmers on Santo report having permanent water available for cattle for the majority of the year. Farmers in East Santo identify lack of drinking water as the second most significant issue, after access to capital, constraining cattle productivity now and in the future (LS-2014-037 surveys). Cattle typically survive normal dry seasons (July to October each year) where rainfall is reduced (50 to 100 mm/month) as pastures will retain some moisture. However, it is likely that dry matter (ME) intake will decline and reductions in productivity will follow (liveweight gain, decreased milk production). With greater climatic variability, it is possible that drier than normal dry seasons (as experienced in 2016) will increase in frequency. Higher mortalities are likely to ensue in these drier years. For example, one farmer typically reported the loss of three breeders (from a herd of 15 breeders) in the dry season each year unless water was transported to the herd. It is likely that calf losses would be higher due to lower milk supply and subsequent dehydration.

Limited options exist for farmers who do not have access to permanent springs and streams. Drilling for sub-surface water may be an option on coastal fringes where a shallow water table exists but is likely to be expensive in areas where the water table is much deeper. Maintenance costs for such infrastructure can be expensive and require specialised skills. Catching and retaining regular rainfall from existing farm infrastructure (e.g. copra driers) is an alternative option, however large storage capacity is required. Pumping from existing permanent water sources is another option but also requires infrastructure and often negotiations with multiple individuals or community groups to access water sources and to navigate land ownership issues. Construction of earthen tanks or dams may be feasible in some areas but many of the soils are free draining or would silt quickly. The bigger picture challenge is that many households do not have access to clean drinking water for household members, and this is rightly a priority before investing in systems to supply drinking water to cattle.

Ultimately, the issue becomes an economic one for farmers. Does the level of productivity (liveweight gain, reproduction rates, mortality) in response to the supply of drinking water warrant the investment in appropriate infrastructure over the medium- to long-term? To assist smallholder farmers make these decisions, local-evidenced based information is required on the likely return on any investment in water infrastructure. For example, liveweight gain of growing cattle offered restricted amounts of drinking water, milk production and calf growth of cows offered limited amounts of drinking water, seasonal changes in pasture moisture content and what amounts of water, and hence type of infrastructure, a typical smallholder cattle herd may require to provide water throughout the year.

Materials and methods

Water requirements model

A simple excel model was developed to estimate total and hence drinking water requirements for a herd of smallholder cattle in Vanuatu. The model incorporates measured data on moisture content of pastures across the year, utilises long-term monthly rainfall data from Pekoa weather station, and recommended water requirements for different classes of cattle under the temperatures ranges experienced in East Santo from existing feeding standards (Freer et al., 2007). The model then estimates the drinking water and water storage requirements to maintain a supply of water for the herd throughout the year.

Response of growing heifers to drinking water availability

An experimental site was established at the Vanuatu Agricultural Research and Technical Centre, East Santo (15°26'58.27"S; 167°11'40.53"E), with two adjacent 2.5 ha paddocks based on *Panicum* (C1) pastures (Figure A2.52). Each paddock had little to no shade, contained a 1500 or 1800 L water trough and approximately 2000 kg pasture DM/ha at the start of the experiment (July-2019). Rainfall was measured using a tipping bucket gauge with a data logger (Rainwise) situated approximately 200 m from the experimental site. It was proposed that the experiment be conducted over two consecutive years with growing heifers, followed by two consecutive years with lactating cows with calves at foot, with cattle replaced each year.

In July-2019, Charolais (n=6) and Local (n=4) heifers (200 ± 36 kg liveweight; mean ± SD) were ranked on liveweight within breed and allocated to Water (n=5) or Restricted Water (n=5) treatment groups and allocated to separate paddocks. Heifers were rotated between paddocks every month. Every 28 days both groups were moved to the VARTC cattle yards and liveweight was recorded after a 12-hour feed and water curfew. Group based faecal samples were collected at weighing for F.NIRS analysis of diet quality and FECs for internal parasites. Dry matter content and availability of pasture was assessed by taking five random 0.7 x 0.7 m quadrats in each paddock cut to 15 cm above ground level. Harvested pasture samples were dried to a constant weight at 60°C. Samples were submitted for F.NIRS and FECs as described elsewhere in the report (Appendix 2.1, Materials and Methods).

Heifers in the Water treatment had *ad libitum* access to drinking water with the water trough turned on throughout each month. Heifers allocated to the Restricted Water treatment had access to water in the water trough for 24 hours every 14 days. The water trough was then emptied and remained empty for the remaining 13 days of the fortnight. The *ad libitum* water trough was emptied after heifers were removed and rotated to the other paddock every 28 days.

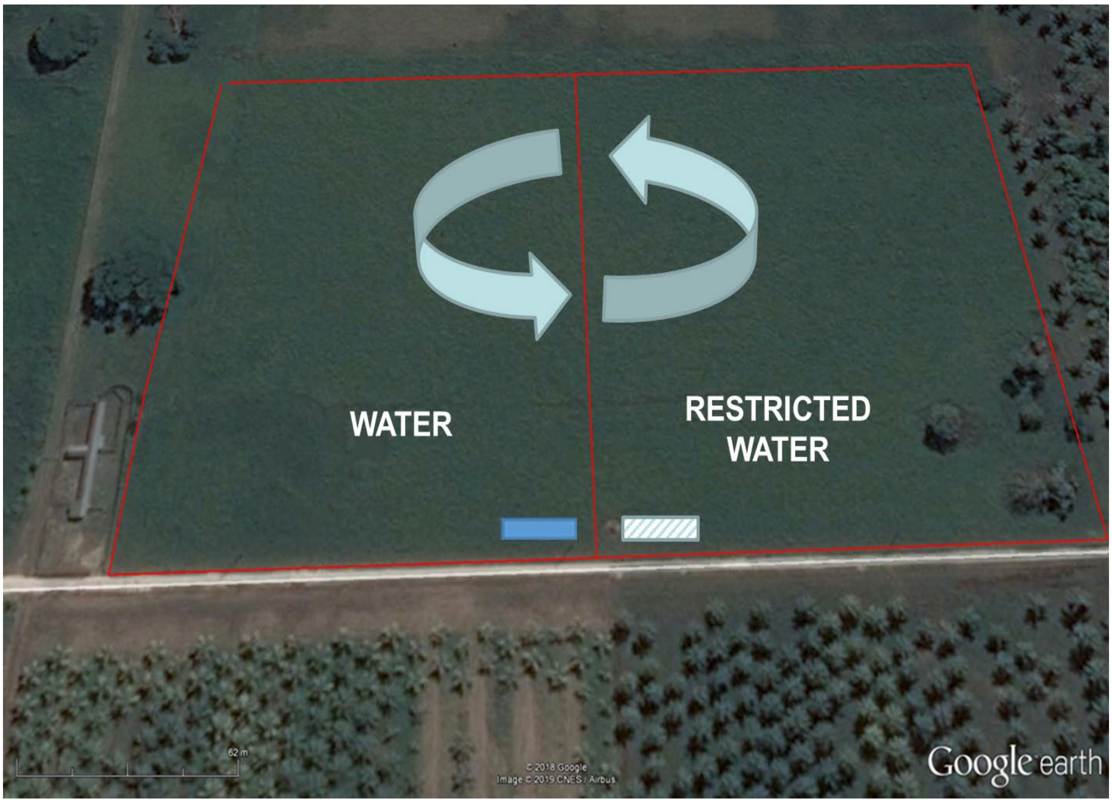


Figure A2.52. Layout of water intake experiment on VARTC.

Results and discussion

Excel model

An excel model has been made available to senior Department of Livestock, Department of Industry and VARTC officers and is available for use by extension and industry officers.

Heifer responses to water supply

Preliminary data from the first 6 months (July-2019 to January-2020) was available from the heifer experiment at VARTC. Rainfall was greater than 50 mm for each month of the experiment (Figure A2.53).

The moisture content of pasture did not differ between paddocks or between months and ranged from 670 to 730 g water/kg fresh pasture from July to December-2019. Predicted crude protein content and dry matter digestibility were unaffected by treatment and consistent across months ranging from 113 to 134 g CP/kg DM and 600 to 640 g digestible DM/kg DM intake, respectively. The proportion of non-grass in the diet was predicted to be 0%, suggesting no or low amounts of legumes were consumed by cattle in both paddocks. These data suggest that the diets consumed by cattle and the availability of water in the ingested pasture were similar between the two paddocks over the first 6 months of the experiment. Therefore, any differences in the liveweight gain of heifers were attributed to water availability and its effect on pasture intake.

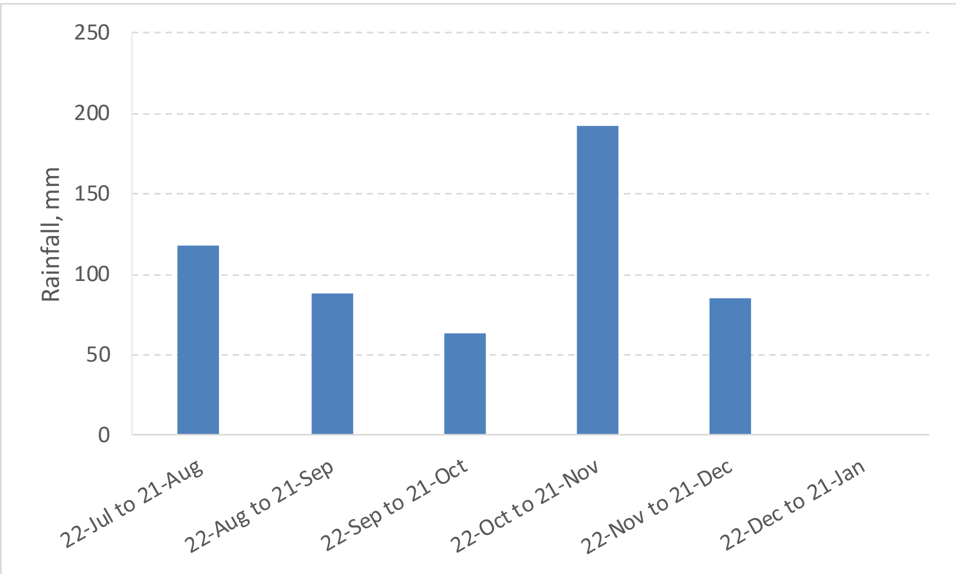
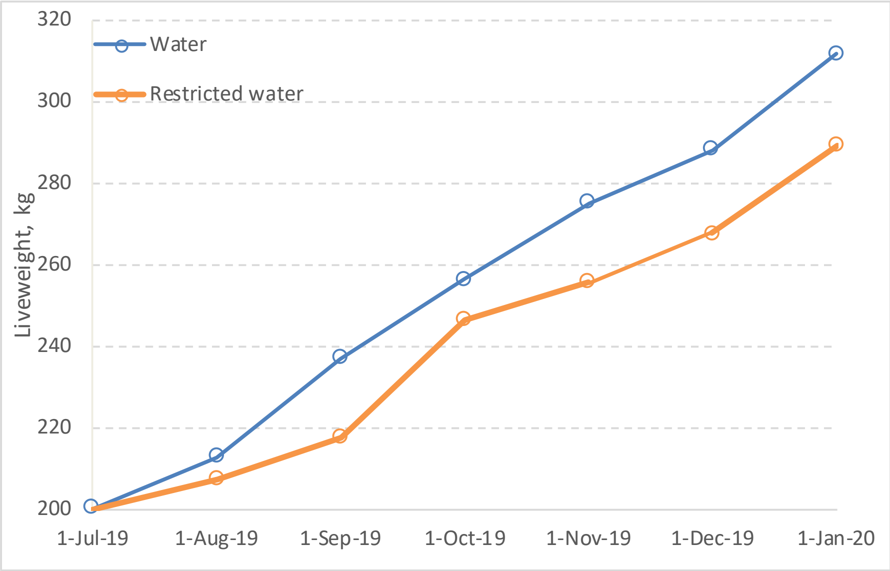


Figure A2.53. Rainfall each month of the experiment recorded on site.

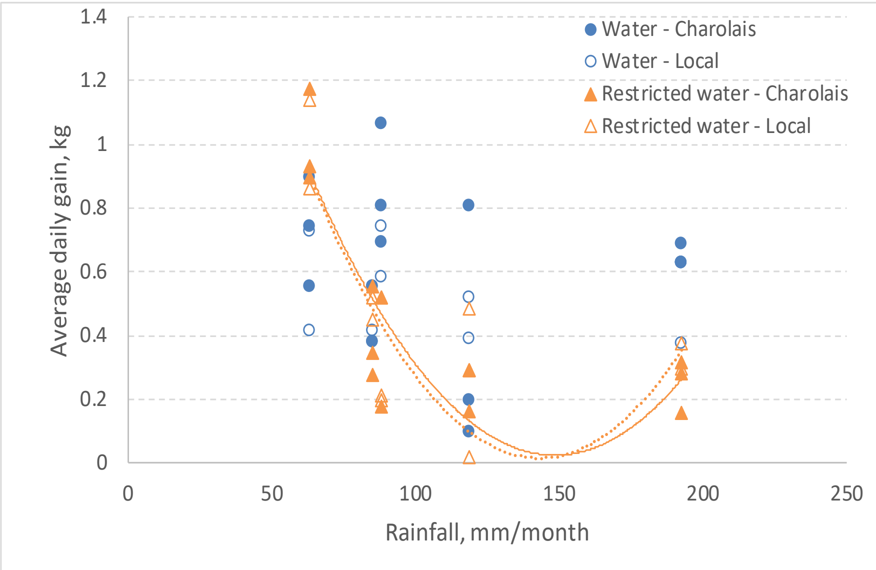
Heifers with *ad libitum* access to drinking water gained 0.61 kg/day over the 6 month experimental period completed to date, compared to 0.50 kg/day for heifers that had access to drinking water for 24 hours every 14 days over the same period. This is equivalent to an extra 20 kg liveweight per heifer (Figure A2.54), or 40 kg of liveweight/ha over 6 months. Whilst the difference between treatment groups is relatively small, liveweight gain of heifers with *ad libitum* access to water have less variable growth rates over the 6 month period (0.40 to 0.80 kg/day on a monthly basis) compared to heifers with restricted water access (0.25 to 1.0 kg/day). The reason for the spike in liveweight gain in heifers with restricted access to water in October was unknown but was significantly higher than for other months and resulted in a negative quadratic relationship between average daily gain and monthly rainfall across the experimental period (Figure A2.54). Higher liveweight gain in the dry season was reported for cattle in Vanuatu and is speculated to be due to an increase in the dry matter content of pastures in response to the higher rainfall (various personal communication). This does not appear to be the case in this dataset as the pasture dry matter content had been relatively constant between months (and treatments). There was little difference in the average daily gain between the Charolais (0.58 kg) and Local (0.52 kg) heifers over the same period.

Cattle in Vanuatu, and probably other areas in the wet tropics, appear unique in that they can survive on moisture available in pastures for extended periods. The current preliminary results would suggest that the continuous supply of drinking water would result in a small increase in productivity compared to the less frequent supply every 14-days. The results should be viewed with some caution as:

1. The Restricted water allowance was more than what most smallholder farmers would supply to their cattle,
2. The seasons the experiment was conducted has thus far had an average or above average rainfall,
3. Pasture biomass was not limiting, so water was available in the form of feed whereas in many smallholder systems pasture biomass is much lower (<1000 kg DM/ha) and may further limit the amount of water available to cattle in these systems, and
4. There is no legume or browse in these diets whereas smallholder cattle may have access to succulent browse and weeds and obtain water from these plants.



a.



b.

Figure A2.54. Change in liveweight of heifers with *ad libitum* (Water) or restricted (Restricted Water) access to drinking water (a.) and the relationship between average daily liveweight gain and rainfall each month (b.).

Conclusions and recommendations

A simple excel model may assist both extension officers and farmers to make decisions regarding their investments in water supply systems to cattle. However, despite its availability there has been no interest from any officers for training or testing of the model. It is too early to make any conclusions regarding the response of heifers to drinking water. The experiment needs to be conducted over wet and dry seasons over multiple years. It is proposed that the current method of supplying water every 14 days be reviewed with potential adjustments made to better reflect the smallholder systems of providing no water at all to cattle. There are many variations that could be tested (lower biomass, increased shade, different pasture-mix, and different physiological status) and it is proposed that further discussions determine priorities for testing in the Phase 2 project, both on-station and on-farm.

References

Ag Excellence Alliance. 2014. *Smartphone apps for smart farmers, version 2*.

Areghoere EM. 2003. *Feeds and forages in Pacific island farming systems,* The University of the South Pacific, School of Agriculture, Animal Science Department, Alafua Campus, Apia, Samoa. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.581.9881&rep=rep1&type=pdf

Aregheore EM. 2005. Evaluation and utilization of Noni (*Morinda citrifolia*) juice extract waste in complete diets for goats. *Livestock Research for Rural Development*. http://www.utafoundation.org/Irrd1704/areg17039.htmAreghoere 2005

Anantharaj A, Jeyakumar S, Sathya MM and Sunder J. 2017. Biochemical and antioxidant effects in crossbred calves fed with *Morinda citrifolia. Journal of Applied Animal Research*. **45**, 252-255.

Baumuller H. 2018. The little we know: an exploratory literature review on the utility of mobile phone enabled services for smallholder farmers. *Journal of International Development*. **30**, 134-154.

Brioudes A. 2016. *Livestock disease surveillance and biosecurity priorities in the Pacific island countries and territories*. PhD thesis, James Cook University. pp 288.

BOM. 2020. Pacific Climate Change Data Portal, Bureau of Meteorology, Commonwealth of Australia. http://www.bom.gov.au/climate/pccsp/

Cardno. 2014. *Vanuatu Beef Value Chain Analysis,* Commissioned by New Zealand Ministry of Foreign Affairs and Trade. Available from Ministry of Tourism, Trade, Commerce, and Ni-Vanuatu Business, Government of the Republic of Vanuatu.

City Population. 2020. Vanuatu Area Council maps. https://www.citypopulation.de/en/vanuatu/admin/?mode=density&map=simple&opacity=0.8&label=name

Coates DB. 2004. *Faecal NIRS: Technology for improving nutritional management of grazing cattle.* Final report of project NAP3. 121, Meat and Livestock Australia, Sydney.

Cook BG, Pengelly BC, Brown SD, Donnelly JL, Eagles DA, Franco MA, Hanson J, Mullen BF, Partridge IJ, Peters M and Schultze-Kraft R. 2005. *Tropical Forages: an interactive selection tool*. [CD-ROM], CSIRO, DPI&F (Qld), CIAT and ILRI, Brisbane, Australia.

Cox K, Keating M, Dayes S and Gardiner C. 2012. Low-input, high quality legume hays for north Queensland. *Proceedings of the 16th Agronomy Society of Australasia Conference,* Armidale, 14-18 October-2012.

Da Silva T, 2017. Compensatory and catch-up growth in cattle. PhD Thesis, The University of Queensland, Australia. pp. 251.

Dairy One. 2019. Interactive Feed Composition Libraries. https://dairyone.com/services/forage-laboratory-services/feed-composition-library/interactive-feed-composition-libraries/

Ehrlich WK, Upton PC, Cowan RT and Moss RJ. 1990. Copra meal as a supplement for grazing dairy cows. *Proceedings of the Australian Society of Animal Production*. **18**, 196-199.

Feedipedia. 2019. Feedipedia: Animal feed resources information system. https://www.feedipedia.org/

Freer M, Dove H and Nolan J (Eds). 2007. *Nutrient requirements of domesticated ruminants*. CSIRO Publishing: Melbourne Vic. Australia.

Gulbransen B, Standfast NF and Kempton TJ. 1990. Supplementation of grazing steers with copra meal. *Proceedings of the Australian Society of Animal Production*. **18**, 236-239.

Lowe KF, Gobius N, Bowdler TM, Casey N and Lowe SA. 1998. *Evaluation and development of persistent legumes in sub-tropical dairy pastures*. DAQ139 DRDC Final Report.

MacFarlane DC. 1998. *Grazing livestock in the Southwest Pacific*. Food and Agriculture Organisation, Apia.

McFarlane D and Shelton M. 1986. *Pastures in Vanuatu*. ACIAR, Technical Reports Series No. 2. Canberra, ACT.

McLennan SR. 2004. More effective supplements for the northern beef industry. Final Report, Project NAP3.122. Meat and Livestock Australia, North Sydney, NSW. http://www.mla.com.au/Research-and-development/Search-RD-reports/RD-report-details/Productivity-On-Farm/Developing-Improved-Supplementation-Strategies/2005

NZMFAT. 2017. *Vanuatu Beef Cattle: The industry's development plan*. Unpublished report. New Zealand Foreign Affairs &Trade, Wellington, New Zealand.

PARDI. 2011. *Canarium Nut Value Chain Review*. https://lrd.spc.int › doc_download › 2252-pardicanariumchainreview-jan-14

Pryor J. 2013. *Phone app for pasture management – overview of development*. Meat and Livestock Australia, North Sydney, Australia.

Quantin P. 1982. *Vanuatu – Agronomic potential and land use maps. Explanatory notes*. Ministry of Land and Natural Resources, Government of the Republic of Vanuatu.

Roxburgh C, Gregory A, Hall J, Higgins S, Titus A, McGill D, Hetherington J and Ross C. 2017. *At-scale evaluation of digital data collection apps in ACIAR projects: Mobile Acquired Data phase 2 (MAD2)*. ACIAR, Canberra, Australia.

Schandevyl P and Deleu D. 1985. Diseases and parasites of cattle in Vanuatu. *Australian Veterinary Journal*. **62**, 297-300.

Simeon P and Lebot V. 2012. Spatial representation of land use and population density: integrated layers if data contribute to environmental planning in Vanuatu. *Human Ecology*. **40**, 541-555.

Struthers G and Troost J. 1998. Veterinary services and livestock disease in Vanuatu. *Surveillance*. **25**, 6-7.

Vanuatu Department of Agriculture and Rural Development. 2016. *Vanuatu National Coconut Strategy, 2016-2025*.

Vanuatu National Statistics Office. 2008. *Census of Agriculture, 2007*. http://www.fao.org/fileadmin/templates/ess/ess_test_folder/World_Census_Agriculture/Country_info_2010/Reports/Reports_4/VUT_ENG_REP_2007.pdf

Vanuatu National Statistics Office, 2016, *Vanuatu 2016 post TC Pam Mini-census Report*, Vol. 1, Vanuatu National Statistics Office, Ministry of Finance and Economic Management https://vnso.gov.vu/index.php/2-uncategorised/153-mini-census

Vanuatu National Statistics Office. 2019. Quarterly trade reports. https://vnso.gov.vu/index.php/economic-statistics/trade-news

Yancy JWS, Apple JK and Kegley EB. 2008. Effects of *Morinda citrifolia* (Noni) pulp on growth performance and stress responses of growing cattle. *Arkansas Animal Science Department Report*. **53**, 68-72.