Resilient plants to entice hens outdoors on free range farms

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Foreword

This project was conducted to provide information for free range egg farmers on what to plant and how to plant the range areas. As a result a guideline package on "Pasture, Tree and Shrub Selection and Management on Australian Free Range Egg Farms" was developed. Information for the package was consolidated from a variety of sources including the experiences and knowledge from case study farms in different climatic zones of Australia. The project highlighted the important role perennial pasture plants have by providing ground cover while trees and shrubs are vital in supplying shade and shelter.

This project was funded from industry revenue which is matched by funds provided by the Australian Government.

This report is an addition to Australian Eggs Limited's range of peer reviewed research publications and an output of our R&D program, which aims to support improved efficiency, sustainability, product quality, education and technology transfer in the Australian egg industry.

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About the Author

Dr. Carolyn de Koning's original research discipline was pasture variety development, ecology and agronomy. In the last six years Carolyn has redirected her skills and experience into free range poultry research with a particular emphasis on the outdoor range environment. Free range poultry projects have included "saltbush on free range farms" and "Determination of range enrichment on commercial layer farms".

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Executive Summary

Plants (ground cover and trees) grown on free range layer farms provide a vital role by enriching the outdoor range and creating an attractive area for hens to go outdoors and explore. However, specific information on what to grow and how to go about sowing pastures and planting trees/shrubs is not easy to find for free range egg farmers, with material spread across many and varied sources. Therefore, the main aim of the project was to consolidate agronomic information on the how and what to plant while also taking into consideration the main climatic zones of Australia.

The project had three components: 1. Case study farms to see what plant species and how farms establish and maintain vegetation on the range; 2. Development of a guideline package on what and how to plant a range; 3. The planting of perennials to enhance the outer range areas to increase utilisation by hens. Information generated from components 1 and 3 were incorporated into the guideline package.

1. **Case study farms**

Case studies were based on fixed range free range farms, whereby the focus was on what was planted/growing on the range and how the farms managed ground cover and trees. The case study farms were located in different climatic zones and were visited up to twice per year corresponding with flocks at peak lay and when the flocks had matured prior depopulation. Farms were located in the temperate - Mediterranean climatic zone (Farm 1), temperate - cool (Farm 2), subtropical (Farm 3) and temperate – no dry season with warm summers (Farm 4). Farms were visited during 2018 and 2019.

A common finding was all farms had sown perennial pasture plants. Lucerne (*Medicago sativa*) was the most widely sown perennial legume, except where the soil pH was highly acidic (Farm 4). Whereas the perennial grass species were more varied, with the subtropical Rhodes grass (*Chloris gayana*) sown in the subtropical zone and perennial ryegrass (*Lolium perenne*) in the cool temperate and temperate zones with high rainfall. However, during the project all farms had been impacted by drought conditions restricting growth of ground cover and the re-sowing of ranges. Native trees and shrubs were typically planted on the range, with wattles being utilized on two of the four farms.

Plumage score and beak shape score of hens were recorded for farms 1 and 2 as an indicator of the level of feather pecking. Regardless of the outdoor stocking density (1,500 v 10,000 hens/ha), ranging hens had better plumage than hens in the shed ($P < 0.01$ and $P < 0.001$ for stocking density respectively). Interestingly beak shape score revealed proportionally more hens outdoors with the larger lower beak step ($P = 0.022$). The significance of this finding is yet to be determined.

Details on ground cover changes across the range measured on Farm 1 showed clearly that ground cover percentage and pasture height increased moving away from the shed. Botanical composition was also influenced by distance from the shed. For example, lucerne was more dominant further away from the shed particularly in early summer when annual plant species had died off.

2. **Development of guideline package**

Information within the package is generic and aimed for first time egg farmers with very little or no agronomic experience. Chapters cover topics such as: Australian climate and soils; Setting up a new range; Regenerating a current range; Establishing trees and shrubs for shelter; Managing nutrient run-off; Poisonous plants and the Case study farms.

3. Perennials on the outer range

A 'proof of concept' trial was conducted on-farm in the temperate (Mediterranean) climatic zone. The aim was to determine whether a sown perennial forage variety (e.g. Lucerne) and a fast growing shrub (Oldman saltbush – *Atriplex nummularia*) on the outer range area (sown at a distance greater than 50 m from the shed) would encourage more birds to venture further onto the range and increase the area of range utilized by hens. Saltbush was chosen because of its wide adaptation and drought tolerance. Saltbush was planted on the ranges of two sheds with an outdoor stocking density of 10,000 hens/ha with a flock size of 30,000 hens. The results were outlined in the guideline package as case study Farm 5. Despite dry conditions for two consecutive years saltbush survival was 41% and 51%. Saltbush seedlings planted in spring 2017 had reached 1 m tall, whereby saltbush planted in spring 2018 had reached a height of at least 50 cm by October 2019.

The hypothesis of sowing perennials on the outer range (50m < from the shed) to attract more hens out to use this area of the range could not be proven. Due to dry conditions the inter rows between the saltbush rows were not sown with lucerne or annual medic species. The addition of lucerne or annual medic may have added to the attractiveness of the range. Although, hens were utilising the range as far as 150 m from the shed and this was evident by the percentage ground cover disappearance. Wildlife cameras had been placed on the outer range from 2 August 2019 to 9 October 2019 to determine the frequency of visits by hens to the outer range area. Cameras were positioned 70 m and 120 m from the shed and 8 m from saltbush. Video showed hens would follow the rows of saltbush and were using the saltbush for shelter, dustbathing under and foraging around. Also, weather was a major influence on hens visiting the outer range, with temperatures above 25^{o}C less favoured by hens as were windy conditions.

The main output from this project was the guideline package, titled "Pasture, Tree and Shrub Selection and Management on Australian Free Range Egg Farms." Incorporated within the package are the experiences and knowledge from the case study farms, all of which were impacted by drought at the time of the study. The dry conditions highlighted the importance of perennial ground cover plants and the utilization of trees and shrubs on the range.

Overall Conclusions

- Perennial pasture plants are very important for free range layer farms, with both perennial grasses and perennial legumes utilized. When annual species had died off for the season, perennials provided some green ground coverage, this was most evident on those farms in the temperate (Mediterranean) zone during summer.

- It was difficult to achieve even usage by hens across the range. Hens utilize the areas closest to the shed more often. In addition, temperature and wind strength are strong modifiers of the hens willingness to go further afield. Hens are less likely to venture to the outer range if temperatures are above 25^{o}C and it is windy. Ground cover is denuded close to the shed with progressively more coverage moving further from the shed.

- Botanical composition of the ground cover species will change according to the distance from the shed. This is a direct influence of the level of hen activity; with more activity and hen numbers closest to the shed and less activity and hen numbers furthest from the shed. Weed species tend to be present closest to the shed.

- Drier climates and/or drought conditions limit the opportunities for free range farms to re-sow ground cover on the range and plant trees/ shrubs. However, free range farms in drier climatic zones can benefit from growing shrubs like Oldman saltbush.

- Case study farms were actively re-sowing ranges when climatic conditions permitted and approached the task with agronomic consideration for correcting soil issues such as heavy clays and acidic soils. (e.g. gypsum and lime respectively).

- Tree and shrubs played a vital role on the range providing shade, shelter and dustbathing sites. All farms were actively planting trees and shrubs with hardy local species used. Furthermore, trees needed protection around the root zone from hen activity especially ranges stocked at 10,000 hens/ha.

- Ranging hens from both outdoor stocking densities of 1,500 and 10,000 hens/ha had better plumage condition. Distribution of beak shape scores of outdoor hens were different to indoor hens. Further research into the ability of hens to range based on their beak shape score is warranted.

- The main output from this project is the guideline package, which consists of general agronomic information on how and what to plant. Case study farms added significantly to the package with their experience and knowledge on the plants they used on the range.

1 Introduction

1.1 Background

Free range represents a high percentage of the Australian egg industry at 47% of eggs sold by volume and 56% in sales value (Australian Eggs Annual Report 2019). As a result, hen welfare issues and consumer affairs (particularly those related to free range egg labelling) have demanded a consistent national standard. The free range information standard requires "hens to have meaningful and regular access to the outdoor range"[1]. The appearance of the outdoor range area and how this is perceived by consumers will also grow in importance. The main challenge therefore is to provide an outdoor range area attractive to hens with resilient vegetative cover all year round. This is especially difficult for fixed free range farms as vegetation closest to the shed is denuded relatively quickly once the birds start ranging. Farm visits at the time of the Poultry CRC free range survey (Singh et al. 2015) had revealed significant issues with maintaining vegetation on fixed range farms. Most layer farms in the survey did not re-sow their range areas or use irrigation on the range. Farmers want information on the establishment and maintenance of range vegetation. Agronomic information on what to plant, how to plant and when to plant (both trees and pasture species) is available but is not found in the one convenient package for egg farmers. In addition, there are perennial plants available that may attract more hens to the outer range and utilize this area more effectively. Over-head cover provided by hardy shrubs and small trees will also add to the attractiveness of the range by providing shade and protective shelter for hens whilst on the range, but information on how to plant and maintain trees on free range farms is lacking.

There are studies that specifically addressed resilience of forages used in free range poultry production, but they are based on overseas research with species suited to high rainfall temperate climates (Buchanan et al. 2007; Breitsameter et al. 2013, 2014). Trials conducted by Breitsameter et al. 2013 and 2014 were small scale, short-term and do not reflect the long term persistence of forage species under commercial layer flock activity in Australia. Breitsameter et al. (2013, 2014) in their studies revealed the most hen resistant species were *Festuca arundinacea* (tall fescue) and *Poa supina* (supina bluegrass). Both species are suited to cooler climates with mild summers. The limited research from Australia (Glatz and Ru 2004) examined the medium rainfall (445mm average annual rainfall) sheep-cereal zone in South Australia. All the plant species in the trial were annuals and in summer only dry residues remained. Dal Basco et al. (2014) examined range enrichment in Italy with naked neck meat chickens. The plant species present on the range were a mix of annual and perennial species typical of a Mediterranean climate with seasonal differences in plant cover and species composition. Dal Basco et al. (2014) found more bare ground in summer and the greatest ground cover in winter; this was partly attributed to less activity of the meat chickens during winter. Maintaining plant ground cover immediately surrounding the shed (up to 30 – 50m distance from the shed) is not possible under fixed free range layer production systems in Australia, with the majority of birds outside using this area. Therefore it is important to make the outer range area (beyond 50m from the shed) attractive to more hens.

Feather condition is an indicator of hen welfare, with damaged and missing feathers showing that injurious pecking has occurred. Studies have shown hens on the range have better feather condition than those that stay in the shed (Chielo et al. 2016; Rodriguez-Aurrekoetxea and Estevez 2016), furthermore those birds furthest on the range had the least damage (Chielo et al. 2016). More hens outdoors and using the outer range area is better for hen welfare. Planting hardy perennials on the outer range maybe a strategy to entice more hens to frequent this under- utilised area of the range.

1.2 Objectives

The main objective is to increase hen welfare by enticing more hens outdoors on fixed free range farms through resilient ground cover and trees.
The aims of the project are;

- Firstly, examine fixed range farms that are successful with maintaining vegetative coverage and trees. Identify resilient plants and formulate bench marks for maintaining vegetation on the range.
- Secondly, compile agronomic information on what to plant, how and when and present in the one convenient package for egg farmers.
- Thirdly, test the hypothesis that perennials planted on the outer range (greater than 50m from the shed) area will attract more hens to utilize this area.

2 Methodology

There were three components to this project (Case study farms 2.1, Guideline package 2.2 and Perennials on the range, proof of concept 2.3). The main output from the project was the development of the guideline package (2.2). Information generated from case study farms (2.1) and perennials on the range (2.3) were also incorporated into the guideline package.

2.1 Case study farms

Case studies were based on fixed range free range farms, whereby the focus was on what was planted/growing on the range and how the farms managed ground cover and trees. The case study farms were located in different climatic zones and were visited up to twice per year corresponding with flocks at peak lay and when the flocks had matured prior depopulation. Farms were located in the temperate - Mediterranean climatic zone (Farm 1), temperate - cool (Farm 2), subtropical (Farm 3) and temperate – no dry season and warm summers (Farm 4). Farms were visited during 2018 and 2019.

2.1.1 Hen measurements

On two of the case study farms (Farm 1 and 2), flocks were selected that had started ranging. Plumage condition and beak shape score were assessed as an indication of the level of feather pecking within a flock. Flocks had plumage scores made on 100 randomly selected birds at different locations within the shed and 100 randomly selected birds across the different areas of the outdoor range. The AssureWel (http://www.assurewel.org/layinghens/featherloss) score system was used, whereby;

0 = no or minimal feather loss (no bare skin visible, no or slight wear, only single feathers missing),
1 = slight feather loss (moderate wear, damaged feathers or 2 or more adjacent feathers missing, bare skin visible <5 cm maximum dimension).
2 = moderate/severe feather loss (bare skin visible ≥5 cm maximum dimension).
Scores were made across five different body parts of the hen which included; head/neck, back, base of tail/around preen gland, the tail and wings. A total plumage score was calculated for each hen by adding the five body part scores together (maximum score = 10).

Beak shape scores were also taken and based on the percentage of acceptable beak shapes 3 + 4 + 5, from the manual by Glatz and Runge (2017), "Managing Fowl Behaviour - A best practice guide to help manage feather pecking and cannibalism in pullet, layer and breeder flocks." Published by Australian Eggs. Fifty random hens from throughout the shed and 50 random hens outdoors were beak scored.

2.1.2 Information collected

Information was collected on the following;

- Length of time the farm has been operating
- Range size, range shape, locality of the shed within the range area
- Shed type; one side with pop-holes or two sides with pop-holes
- Flock size, flock age and outdoor stocking density
- Percentage of total flock on the range during the visits, where on the range and what was the main activity of the hens
- At each visit the condition of the ground cover vegetation on the range was assessed
- Weed species identified
- Tree type, location on the range, number and age of trees
- Tree planting strategies used on farm (e.g. species and type of tree guards)
- Practices used to manage the range vegetation (e.g. rotation time between different areas of the range, frequency of mowing).

Bench marks for the successful maintenance of vegetation on the range will be formulated based on the information collected. They will be related to regional conditions (eg. rainfall and main soil type). Those plants that are surviving hen activity will be identified and compared to the plants recommended for the region (component 2) to see if there is commonality. Plant species survival will also be related to distance from the shed. This information will indicate whether some plants (with emphasis on non- weed species) can tolerate growing closer to the shed better than others.

2.1.3 Ground cover measurements

Ground cover was measured in detail on Farm 1. Pasture measurements of percentage green ground cover (visual score 0 to 100%), pasture height (cm), and botanical composition (dry weight rank method converted to percentage, Mannetje and Haydock 1963) were made at 10 m, 20 m and 40 m from the shed along four transects (2 transects each side of the shed). At each distance (10, 20 and 40 m), 10 quadrats (50 x 50 cm) were assessed. The main plant species used for ranking were, lucerne, lagoon saltbush, annual ryegrass, marshmallow, shepherd's purse and wireweed. Measurements were made in 2018 and 2019.

2.2 Guideline package

Some information on pasture choices for free range poultry has been described in the "AgGuide – Getting started in free range poultry" (published 2009, NSW Government – Industry and Investment). The guideline package will greatly expand on this information. Agronomic practices relevant to free range egg farms in both winter dominant and summer dominant rainfall zones was compiled. Information collected included what to plant, when to plant, how to plant range plants (trees, shrubs and ground cover). Much of this information is available but it is spread across numerous and varied sources. Historic recommendations of plant species prior to industry moving into cages were re-visited. This included species such as Tagasaste/Lucerne tree and Rhodes grass. The agronomic information is presented to egg farmers in the one package and took into account different seasonal rainfall patterns (winter dominant and summer dominant) and the main soil types. A consultant, Michael Wurst (PIRSA Rural Solutions) with the skills to package extension material was contracted.

2.3 Perennials on the range 'Proof of concept'

A 'proof of concept' trial was conducted on-farm in the temperate (Mediterranean) climatic zone. The aim was to determine whether a sown perennial forage variety (e.g. Lucerne) and a fast growing shrub (oldman saltbush – *Atriplex nummularia*) on the outer range area (sown at a distance greater than 50m from the shed) will attract more birds further out onto the range to increase the area of range utilized by hens. Saltbush was chosen because of its wide adaptation and drought tolerance.

The hypothesis being tested is that more hens will be attracted to an outer range area planted with both perennial ground cover and fast growing shrubs.

Two sheds/flocks were the focus of this study. In 2018, one shed had run a Hy-line Brown flock (flock E1) and the other shed a Lohmann Brown flock (flock E2). The flock size was 30,000 birds with an outdoor stocking density of 10,000 birds/ha. In 2019, both sheds in the study housed Hy-line Brown flocks (flock F1 and flock F2). Even at this stocking density past flocks have not fully utilized the range area available to them. The total range area available for each flock was 4 hectares. Three hectares of the range area was situated West from the shed. The North and South ranges were 0.5 ha each.

The proposed range treatments were;

1. Saltbush planted with Lucerne sown in between saltbush rows.
2. Control, unsown existing background vegetation.

The outer range was defined as starting at 50m from the shed. The area for each treatment plot was large, 150m long x 16m wide and starting 50m out from the shed. The two treatments were replicated 4 times.

2.3.1 Preparation and planting of saltbush

Areas to be planted were sprayed on 7/09/2017 with Roundup Powermax® (Glyphosate at 3L/ha) and planting rows were deep ripped on 11/09/2017. This was done well before the hens commenced ranging. Deep rip lines had worked well on one range area (shed 1) but the other area had created large clods of soil (shed 2). Saltbush planting was too soon after ripping as the range with clods had caused problems with physically planting seedlings between soil clods and then watering. Water would disappear between soil clods beyond the root zone of the newly planted saltbush. In 2017 saltbush was planted during the driest month of that year (September total = 3.2 mm) and soil conditions were dry on the planting days 27 to 28/09/2017. Another planting of saltbush was made in 2018 (24/08/2018 and 7/09/2018) to fill in some of the gaps due to poor survival from the 2017 planting.

The Oldman saltbush variety "De Kock" came in seedling trays holding 150 seedlings. Just prior to planting, seedlings were popped out from the tray and placed into a 9L bucket with a mixture of 3L water and Seasol®. The bucket could hold at least 50 seedlings. Planting was done using a PottiPutki which is an ergonomically designed manual tree planter. Planted seedlings were protected with green corflute 40 cm high triangular guards and watered after planting.

Four twin rows of saltbush were planted per range 16 m apart. Rows started at least 50 m from the western end of the shed and were 250 m long. Twin rows of saltbush were 4 m apart and within a row saltbush was spaced at 4 m. This gave the option to thin out if necessary in later years.

2.3.2 Vegetation on the range measurements

Saltbush survival was checked by counting live plants in each row (16/3/2018 and 9/10/2019).

Pasture measurements of percentage green ground cover (visual score 0 to 100%) and botanical composition (dry weight rank method converted to percentage, Mannetje and Haydock 1963) were made at 0 m, 20 m, 40 m, 60 m, 80 m and 100 m from the start of the outer range area. For shed 1 the outer range with saltbush started at 70 m from the western side of the shed and 50 m from the western side of shed 2. At each distance (0, 10, 20, 40, 60, 80 and 100 m), 24 quadrats (50 x 50 cm) were assessed (12 quadrats within saltbush rows and 12 quadrats within control sections). The main plant species used for ranking were, carpet weed (*Galenia pubescens*), annual medic (*Medicago* species) and ward's weed (*Carrichtera annua*). Measurements were made in 2018 and 2019.

2.3.3 Hen measurements

Hen measurements of plumage scores and beak shape scores followed the protocols outlined in section 2.1.1. Measurements were made on 16/03/2018 and 9/10/2019.

At each visit, live hen counts on the various sections of the range were made. Temperature, wind strength and weather (e.g. sunny, cloudy, rain) were also recorded.

2.3.4 Wildlife cameras on the outer range

Wildlife cameras (*SIGNIFY*®, Silverwater, NSW, Australia) were placed near the saltbush (8 m away from saltbush rows in replicate 2) to see how frequently the hens used the area in 2019. Two cameras were placed on the range of each shed (Flock F1 and flock F2) at 70 m and 120 m from the shed (Total 4 cameras). Cameras were mounted on steel droppers 1 m high from the ground using cable ties. When triggered by movement cameras were set to take 3 photos in rapid succession followed by a 20 second video. Numbers of hens in the photo frame could be counted and hen activity (walking, foraging, dustbathing and sheltering) could be seen in the video footage. The frequency of hens visiting the area was determined by counting how many times hens appeared during the period the cameras where on the ranges. Operating time for the cameras was from the 2 August 2019 to 9 October 2019. This covered seasonal weather conditions from late winter (cold) to mid spring (hot). Additional information displayed on photos was time of day and temperature. This was used to see what times were popular for hens to be out amongst saltbush and the optimum temperature for hens visiting the outer range. It was also possible to assess basic weather conditions, e.g. sunny, cloudy, overcast, raining and windy. Wind speed was estimated visually from the amount of movement of saltbush branches and ground vegetation (Adapted from the Beaufort wind scale, source www.bom.gov.au). Calm (0 km/hr), no movement of ground vegetation or saltbush. Breeze (19 km/hr or less), ground vegetation starting to sway no movement in saltbush. Windy (20 – 39 km/hr), branches move on saltbush. Very windy (40 – 50 km/hr), whole saltbush being swayed and whistling heard through audio on wildlife cameras.

2.4 Statistical analysis

Hen measurements such as plumage scores were analysed using a two sample T-test with unequal variances. The null hypothesis tested was no differences between the plumage scores for hens inside the shed compared to hens out on the range. A further null hypothesis was tested for trial 2.3; hens found close to the shed (<50 m) were no different in plumage scores than those hens found ranging on the outer range with saltbush (50 m<). Beak shape scores expressed as a percentage were analysed across three farms (Farm 1, 2 and 5) with a total of five flocks. Data was square root transformed and analysed using a two sample T-test with unequal variances. At each beak shape score the null hypothesis was tested for no differences between range hens and hens found in the shed.

Percentage ground cover and percentage botanical composition data were square root transformed before analysis. Pasture height and pasture dry matter production were transformed when required using a $\log_{10}$ transformation. A general analysis of variance (Genstat 19.1 Edition, VSN International, Rothamsted, UK) tested for treatment effects. The main effects tested for case study Farm 1 were distance from the shed and time (age of flock), the interaction distance x age was also tested. For trial 2.3, the main effects were shed, distance from the shed and age of the flock, in addition the interaction distance x age. Because shed effect was found to be significant for all variates ($P < 0.05$), sheds were analysed separately.

3 Results

3.1 Case study farms

The results shown in section 3.1 for the case study farms is similar to the information presented in the guideline package.

3.1.1 Farm 1- temperate (Mediterranean) climatic zone

Average Annual Rainfall & Rainfall pattern; 470 mm, winter dominant rainfall pattern.
Rainfall total 2018 = 250 mm.
Rainfall total 2019 = 252 mm

Soil type; Typically Red Brown Earths have a topsoil of sandy loam to light clay loam overlying a clay subsoil. Soil pH measured in $CaCl_2$ is 6.6 – 7.0 (0 – 30 cm), 7.6 – 8.0 (30 – 60 cm) and 8.1 – 9.5 (60 – 100 cm). Soil pH measures for farms 1, 2 and 4 were obtained from, https://www.nationalmap.gov.au/investormap/

Length of time the farm has been operating; The farm has been running free range layers for over 50 years as part of a broad acre cropping-livestock enterprise. The case study flocks' range area and shed is approximately 5 - 6 years old.

Range size, range shape, locality of the shed within the range area; The shed is located in the centre of a square shaped range area that caters for up to 1,500 hens per hectare. The range area is subdivided into four sections.

Orientation of shed; East – West.
Shed type (1-sided or 2-sided pop-holes); The entire lower half of the North and South facing sides of the shed open to allow hens access to the range.

Additional structures (eg. shade shelters, hay bales) on the range; Shade shelters are located 5 m from the shed on the North and South side of shed.

Flock size and flock age; Total flock 5,000 Hy-line Brown hens (Infra-red beak treated at hatchery), divided into two sub-flocks of 2,500 hens each. The shed was sub-divided down the middle lengthwise and each sub-flock had access to their own range area. Case study visits in 2018 were made when the hens were 32 and 65 weeks old (Flock A). In 2019, the second flock hens were 25 and 41 weeks old during visits (Flock B).

Outdoor stocking density; Up to 1,500 hens /ha.

Observations from farm visits
Percentage of total flock on the range, where on the range and what is the main activity of the hens, and weather conditions at time of visit.

2018: The maximum percentage of the flock outside during the case study visits was 12.5%.
May 2018*:* Most of those hens outside were on the southern side of the shed in the shade cast by the shed. The northern side was more exposed to a moderate northerly wind on the day of the visit.
December 2018: As a result of strong SW winds gusting up to 40 km/hr over 60% of those hens

outside were foraging and dustbathing on the northern side within 10 m from the shed.

July 2019: Seventy-five percent of the flock were outdoors on both sides of the shed, with 20% of the flock at least 10 m away from the shed foraging. The temperature was 14°C with no breeze and the ground was damp from overnight rain.
November 2019: Less of the flock was outdoors with 35% of the flock on the range and 8% of the flock venturing at least 10 m from the shed. The wind was a strong SW at 30 km/hr with a temperature of 16°C.

Plumage condition score and beak shape scores of hens on the range and indoors;

	Hen age (32 weeks)		**Hen age (65 weeks)**	
	Plumage	**Beak ***	**Plumage**	**Beak ***
Range	0.23	94	0.98	92
Indoor (Shed)	0.28	98	1.29	98
Statistical significance	n.s	-	P < 0.01	-

Table 3-1-1. Farm 1 - Flock A, year 2018, average total plumage scores and beak scores of free range Hy-line Brown hens at 32 and 65 weeks stocked at 1,500 hens/ha. *Beak shape score (percentage of acceptable beak shapes 3 + 4 + 5) based on; Glatz P, Runge G (2017) Managing Fowl Behaviour - A best practice guide to help manage feather pecking and cannibalism in pullet, layer and breeder flocks. Australian Eggs, 148 pages.

Plumage condition of flock A in 2018 at 65 weeks was very good, even so those hens on the range had better plumage condition compared to those hens in the shed (Table 3-1-1). Most of the plumage damage was on the tail followed by the neck. Beak shape scores had shown the overall flock average was 96% and 95% at 32 and 65 weeks respectively. This is just below the recommended level of 97% for the age of flock (Glatz and Runge 2017). Interestingly, the birds outdoors were below the recommended level while those hens indoors were above. There were proportionally more birds outdoors with a beak shape score of 6. Better plumage scores of birds outdoors at age 65 weeks may be partly attributed to more birds outdoors with beak score shape 6. Beak shape 6 with a larger beak step would make it more difficult for those birds to effectively peck at other birds.

As hens had extremely good plumage feather scores were not made for the 2019 flock B at age 25 and 41 weeks and only beak scores were assessed. Similarly to the previous flock in 2018, flock B had a greater percentage of acceptable beak shapes for those birds inside the shed compared to outdoors (Table 3-1-2).

	Hen age (25 weeks)*	**Hen age (41 weeks)^**
Range	82 %	86%
Indoor (shed)	94 %	96%

Table 3-1-2. Farm1 – Flock B, year 2019, beak scores of free range Hy-line Brown hens at 25 and 41 weeks stocked at 1,500 hens/ha. Beak shape score * (percentage of acceptable beak shapes 3 + 4 + 5 + 6, birds 12 to 30 weeks of age) and ^ (percentage of acceptable beak shapes 3 + 4 + 5, birds 30< weeks of age) based on; Glatz P, Runge G (2017) Managing Fowl Behaviour - A best practice guide to help manage feather pecking and cannibalism in pullet, layer and breeder flocks. Australian Eggs, 148 pages.

The beak shape score distributions were also different between indoor birds and outdoor birds (Figure 3-1-1). Proportionally more birds are found on the range with a larger beak step (score 7 at 25 weeks & score 6 at 41 weeks) and more birds with score 4 inside the shed. This is similar to the 2018 flock A (data not shown).

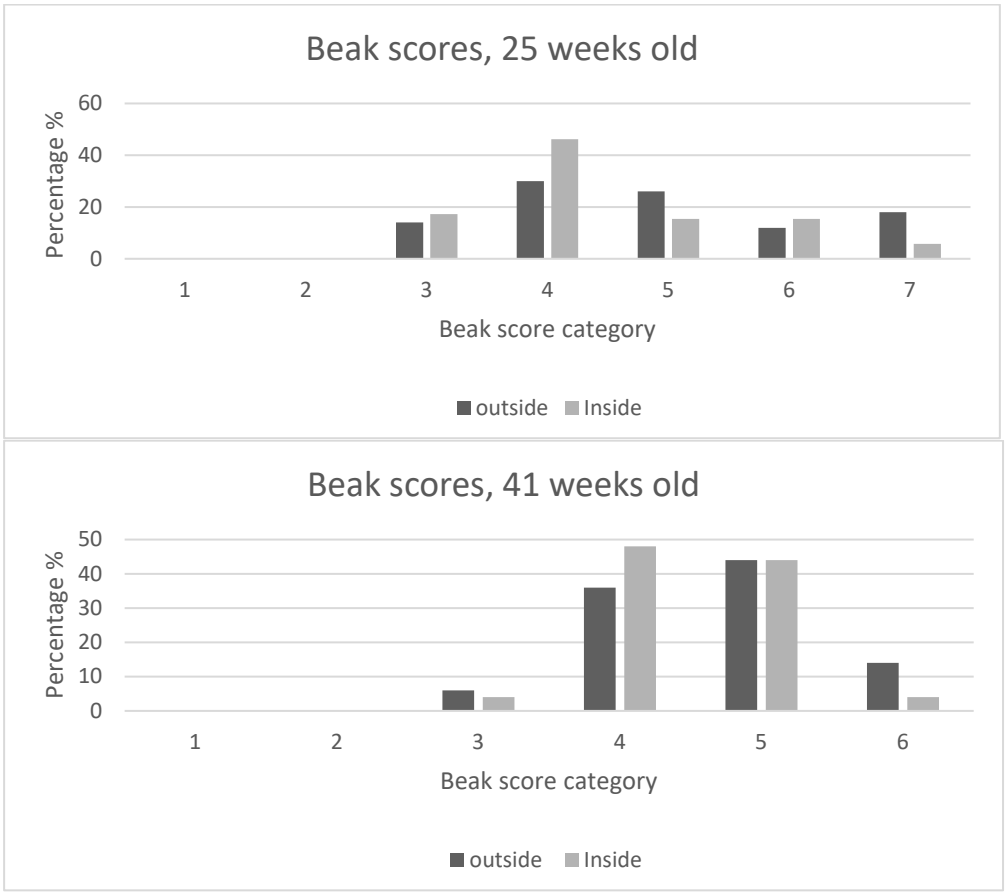

Figure 3-1-1. Beak shape score distribution for the 2019 flock B at 25 and 41 weeks old, inside hens v outside hens.

Ground cover plant species including weed species on the range; 2018 - Lucerne (*Medicago sativa*) had been sown extensively on the range areas of Farm 1 (Figure 3-1-2). A naturalised annual form of saltbush, lagoon saltbush (*Atriplex suberecta*) was also found growing on the range and this plant was most commonly found growing closest to the shed, albeit very well grazed down by the hens. Very few weeds were found and they grew closer to the shed at 10 m and 20 m. Lucerne was dominant at 40 m and beyond with no weeds at this distance from the shed. Weed species included wild mustard (*Sinapis arvensis*), marshmallow (*Malva parviflora*) and wire weed (*Polygonum aviculare*). At 20 m from the shed, lucerne and lagoon saltbush were growing in combination.

Condition of the ground cover vegetation on the range; 2018 **-** In December 2018, green ground cover was 8% at 10 m to 20 m from the shed and 14% at 40 m from the shed. Drought conditions during 2018 had a significant impact on lucerne growth. However, if not for the lucerne and the lagoon saltbush, there would not have been any green ground cover. Pasture height was taller furthest from the shed. Yet, hens had been actively foraging away from the shed as the height of lucerne had decreased from 25 cm tall at 32 weeks down to 15 cm at 65 weeks at a distance of 40 m. The range area surrounding the shed was bared out to around 10 m.

2019 – The area rested during 2018 was opened for flock B during 2019, while the area ranged during 2018 was closed for recovery until November 2019. Green ground coverage was high in July 2019, except at 10 m there was 14% cover, while 20 m and 40 m had 84% and 90% cover respectively. Green ground coverage had dropped dramatically by November 2019, whereby at 10 m there was only 8% green cover, 20 m = 11% green cover and 40 m = 18.5 % green cover. This was largely attributed to the annual plant species dying off at this time of the year; a normal occurrence for

Mediterranean climatic areas. Lagoon saltbush had made an appearance again in November and was mostly found at 10 and 20 m from the shed. In July Lagoon saltbush was not seen. Lucerne was not dominant in July, other species were present such as marshmallow, annual ryegrass (*Lolium rigidum*) and Shepherd's purse (*Capsella bursa-pastoris*). However, in November Lucerne was the most dominant species and remained green while the annual plant species (marshmallow, annual ryegrass and Shepherd's purse) had died off (Figure 3-1-3). The area rested during 2019 had more green ground cover at 20 m (20% cover) and 40 m (31% cover) from the shed in November 2019 compared to the area that had been ranged throughout 2019 (11% and 18% for 20 m and 40 m respectively).

Tree type, location on the range, number and age of trees; Locally adapted Eucalyptus tree species were planted with at least 60 established trees from 1 m to 6 m tall, with an additional 200 younger trees less than 1 m tall. Trees were planted in 5 rows running parallel to the shed, within a row the trees are planted around 5 m apart. The first tree row is adjacent the shed and runs the length of the shed. Further tree rows are approximately 10 m, 25 m, 40 m and 55 m from the shed and run the full length of the range area. Trees were sourced from "Trees for Life". Newly planted trees are protected with 40 cm tall green corflute tree guards.

Practices used to manage the range vegetation (e.g. rotation time between different areas of the range, frequency of mowing); Following sowing, lucerne is usually given at least 12 weeks to establish before hens are allowed to range on the lucerne. The range area is subdivided so there is the ability to rotate between 2 paddocks for each sub-flock. Lucerne on the case study range is surviving. However, due to the drought the older lucerne stands on the farm will need the lucerne re-sown. Consideration is being given to delay placement of those flocks by 12 weeks to allow those ranges time to establish.

A more detailed interpretation of ground cover changes and botanical composition results can be found in a copy of the paper published in the Proceedings of the Australian Poultry Science Symposium (de Koning 2020) (Appendix).

Figure 3-1-2. Left – range in autumn 2018 when hens 32 weeks old & Right – early summer 2018 showing Lucerne when hens 65 weeks old.

Figure 3-1-3. Left – July 2019 the range had at least 90% green ground cover at 40 m from the shed and Right – November 2019 annual plants have died off leaving green Lucerne plants and an average green ground cover of 18%.

3.1.2 Farm 2- temperate (cool) climatic zone

Average Annual Rainfall & Rainfall pattern; 610 mm, uniform rainfall pattern throughout the year.
Rainfall total 2018 = 635 mm. Spring drier than usual.
Rainfall total 2019 = 432 mm.

Soil type; Acidic loam with less acidity at depth. Soil pH measured in $CaCl_2$ is 5.6 – 6.0 (0 – 5 cm), 4.9 – 5.5 (5 – 15 cm), 5.6 – 6.0 (15 – 60 cm) and 6.1 – 6.5 (60 – 100 cm).

Length of time the farm has been operating; 6 years.

Range size, range shape, locality of the shed within the range area; Square range, 19,000m^2. The northern range is twice the size of the southern range. There is no eastern range area.

Orientation of shed; East – West.

Shed type (1-sided or 2-sided pop-holes); Pop-holes are located along the North and South facing sides of the shed.

Additional structures (e.g. shade shelters, hay bales) on the range; There were 10, steel framed shade structures (5 x 5 m) with shade cloth. These were located close to the shed when the flock was young and moved progressively further from the shed as the flock matured. Hay bales had been placed on the range, particularly when the green ground cover had disappeared. The hens scratch through the hay breaking it down into smaller pieces potentially adding organic matter to the soil.

Flock size and flock age; year 2018 - Total 14,880 Hy-line Brown hens (Infra-red beak treated at hatchery). Case study visits were made when the hens were 42 and 72 weeks old (Flock C). During 2019 only one visit was made when the hens were 68 weeks old (Flock D).

Outdoor stocking density; Up to 10,000 hens /ha.

Observations from farms visits
Percentage of total flock on the range, where on the range and what is the main activity of the hens, weather conditions at time of visit;

2018: Fourteen percent of flock C were outdoors at the time of the visits. Hens were found across all parts of the range with at least 50% of those hens outdoors beyond 10 m from the shed. Weather conditions at the time of the visits was cool, partly cloudy with a light breeze.
2019: At least 50% of flock D was outdoors. Of those hens outside, 80% were away from the shed in the wattle groves and under the cypress pines along the perimeter fence. There were very few hens using the constructed shelters adjacent to the shed. Weather conditions were sunny, no breeze and 21°C.

Plumage condition score and beak shape scores of hens on the range and indoors;

	Hen age (42 weeks)		**Hen age (72 weeks)**	
	Plumage	**Beak ***	**Plumage**	**Beak ***
Range	1.27	93.0	3.22	93.8
Indoor (Shed)	2.06	94.0	4.43	94.6
Statistical significance	P < 0.001	-	P < 0.001	-

Table 3-1-3. Farm 2 – flock C, 2018, average total plumage scores and beak shape scores of free range Hy-line Brown hens at 42 and 72 weeks stocked at 10,000 hens/ha. *Beak shape score (percentage of acceptable beak shapes 3 + 4 + 5) based on; Glatz P, Runge G (2017) Managing Fowl Behaviour - A best practice guide to help manage feather pecking and cannibalism in pullet, layer and breeder flocks. Australian Eggs, 148 pages.

	Hen age (68 weeks)	
	Plumage	**Beak***
Range	1.45	86.0
Indoor (Shed)	2.56	94.0
Statistical significance	P < 0.001	-

Table 3-1-4. Farm 2- flock D, 2019, average total plumage score and beak shape scores of free range Hy-line brown hens at 68 weeks stocked at 10,000 hens/ha. *Beak shape score (percentage of acceptable beak shapes 3 + 4 + 5) based on; Glatz P, Runge G (2017) Managing Fowl Behaviour - A best practice guide to help manage feather pecking and cannibalism in pullet, layer and breeder flocks. Australian Eggs, 148 pages.

Plumage condition was reasonable considering the age of the hens in flock C. Ranging hens had better plumage condition than shed hens at 42 and 72 weeks (Table 3-1-3). At 72 weeks most of the plumage damage was on the neck, back and base of tail. Beak scores differed slightly. Plumage damage scores of birds on Farm 2 were higher than Farm 1, possibly due to the higher outdoor stocking density. Flock D in 2019 had very good plumage at 68 weeks (Table 3-1-4), considerably better than the previous flock C at 72 weeks of age. Range hens had significantly less plumage

damage than hens in the shed. Beak scores differed between range hens and hens inside the shed with a lower percentage of hens with acceptable beak shapes found on the range. This was due to proportionally more hens with beak shape 6 on the range. Similarly, this was found on Farm 1.

Ground cover plant species including weed species on the range; Wire weed (*Polygonum aviculare*) had been the main ground cover plant on the first visit in March 2018, with almost total cover except for bare ground within 5 m from the shed.

Condition of the ground cover vegetation on the range; The flock of 2017 had relentlessly attacked the newly established pasture species of perennial ryegrass (*Lolium perenne*), red clover (*Trifolium pratense*) and white clover (*Trifolium repens*) during the dry season in 2017 (503 mm annual rainfall). This had led to the dominance of the wire weed in 2018. Green ground cover had been denuded from the range by the time of the second visit at 72 weeks (October 2018). The range was lightly cultivated and re-sown in March 2019 with biennial ryegrass (*Lolium multiflorum*), oats (*Avena sativa*) and white clover in preparation for flock D placement in March 2019. Weather conditions were dry and the hens soon targeted the palatable ryegrass.

Tree type, location on the range, number and age of trees; Trees planted on Farm 2 are locally adapted native species and were sourced from a local nursery as seedlings. Seedlings are grown on into larger pots (up to 30 cm diameter) in the farm's own simply constructed plant nursery (Figure 3-1-4). When the trees reach 1 m tall they are planted out onto the range. At this height, they don't require tree-guards. Tree planting is usually done from March to November, with around 114 newly planted trees in the last 12 months on the case study flock's range. Furthest from the shed along the northern fence line is a row of mature cypress trees. This area of the range has been well utilised by the hens, to the extent that the trees needed their root zone protected with large rocks. Young black and silver wattles (*Acacia mearnsii* and *A. dealbata*) planted on the range were growing particularly well and had reached over 3 m tall in 2 years. Wattles had been planted in circular shaped groves consisting of 18 wattles spaced 3 m apart with a slower growing flowering gum (*Corymbia ficifolia*) in the centre. In total there are six wattle groves planted on the range situated approximately 40 – 60 m from the shed. Hens were observed utilizing the groves for dustbathing, sheltering and resting (Figure 3-1-6). Tree roots remain well protected from hen activities, with large rocks placed at the base of the young trees (Figure 3-1-5). In total the farm has over a 1,000 newly planted trees. On other range areas, trees have recently been planted in twin rows that start near the shed and extend to the outer range to help encourage hens to move further out from the shed.

Practices used to manage the range vegetation (e.g. rotation time between different areas of the range, frequency of mowing); Some range areas on the farm require regular mowing (fortnightly) due to underutilized sections on the range and the fast growth of grasses such as cocksfoot (*Dactylis glomerata*), perennial ryegrass and prairie grass (*Bromus wildenowie*). There is also a background of subclover (*Trifolium subterraneum*). The farm was an ex-dairy property and the grasses and the subclover are the result of what was a well maintained dairy pasture. Nevertheless, grass dominant ranges have been oversown with pasture legumes such as lucerne, red and white clover.

Figure 3-1-4. Farm 2 plant nursery used to grow trees to a larger size before planting on the range.

Figure 3-1-5. Farm 2 wattle planted (1 year since planting) on the range with rocks around the base to protect the roots.

Figure 3-1-6. Wattle groves with trees at least 3 m tall after only 2 years since planting on the range of farm 2, groves are being highly utilised by hens.

3.1.3 Farm 3 - subtropical (summer dominant rainfall) climatic zone

The information presented on Farm 3 is based on two visits with no specific flocks followed. Three systems of free range production are being run on the farm; fixed range 1,500 hens/ha, fixed range 10,000 hens/ha and organic mobile sheds at 1,500 hens/ha.

Average Annual Rainfall & Rainfall pattern; regional rainfall average = 626 mm, summer dominant pattern.
Rainfall total for 2018 = 544 mm.
Rainfall total for 2019 = 169 mm.

Soil type; Clay and heavy loams. Average soil pH in the surface layer is 6.2 (0 – 10 cm) and increases in alkalinity with depth; 7.1 (0 – 30 cm) and 8.8 (50 – 60 cm).

Length of time the farm has been operating; at least 10 years

Range size, range shape, locality of the shed within the range area; Organic production - Rectangular shaped range with the shed in the middle, each range is 3 ha (1.5 ha each side of the shed). Another range area the same size is adjacent, this is used in rotation every 60 weeks. The organic shed is designed to be moved to the adjacent location with every new flock.

Orientation of shed; East-West

Shed type (1-sided or 2-sided pop-holes); 2 sided with pop holes on southern and northern sides.

Additional structures (e.g. shade shelters, hay bales) on the range; long rectangular shade shelters are placed near pop holes (8 – 12 shelters per shed)

Flock size and flock age; Hy-line Brown and Isa Brown, organic flock = 4,500 hens.

Outdoor stocking density; Organic flock = 1,500 hens/ha.

Percentage of total flock on the range, where on the range and what is the main activity of the hens, weather conditions at time of visit; Not assessed on the first visit in 2018. On the day of the second visit in November 2019, it was hot and sunny day with a maximum temperature 36^{o}C. Some hens in all free-range systems had left the shed but did not venture far onto the range and remained close to the popholes or sheltered under the ramps and shade shelters adjacent to the sheds.

Plumage condition score and beak shape scores of hens on the range and indoors; Not assessed.

Ground cover plant species including weed species on the range; The main perennial grasses growing on the ranges are Rhodes grass (*Chloris gayana*), Creeping blue grass (*Bothriochloa insculpta*), African lovegrass (*Eragrostis curvula*), African star grass (*Cynodon plectostachyus*) and un-improved native grass pastures. Lucerne had also been sown on some of the ranges. Kikuyu (*Pennisetum clandestinum*) had been trialled in the past but was too reliant on irrigation to keep it looking good and growing. Mostly Rhodes grass is resilient to hens (Figure 3-1-7), but it can be killed by hens if they are allowed too soon onto new regrowth following mowing. Although another species of Rhodes grass, "Feathertop Rhodes grass" (*Chloris virgata*) has become an issue on some 1,500 hen/ha ranges. It is considered a major weed of broad acre farming enterprises and is a tufted annual that grows to 1 m tall that can readily set and reproduce from seed and competes strongly with more desirable species.

Condition of the ground cover vegetation on the range;
2018 - Despite most ranges being well covered (except closest to the shed) most flocks don't venture much further than 20 – 30 m from the shed. It was noted by the farm manager the hens do not like moving through tall grass. To encourage hens out, corridors were mown through long grass however this still had minimal effect on encouraging more hens further out.
2019 – Drought conditions have impacted pasture growth severely whereby there had been no new growth at the time of the visit in November 2019. Ranges stocked at 1,500 hens/ha had maintained standing dry grass further away from sheds.

Tree type, location on the range, number and age of trees;
Trees and shrubs are locally adapted. Wattles are not being planted because of potential weediness concerns as the farm is located close to native bushland. Newly planted trees on the range are protected with wire mesh guards, not to prevent hen damage but to protect against corellas that nip out growing tips and strip the leaves from young trees. Mulch pads are also used around the base of newly planted trees. They reduce weeds, are designed to funnel light rain and dew onto the root zone and reduce evaporation from the root zone (Figure 3-1-9). Recent tree plantings have been arranged in rows radiating out from the shed onto the range, it's anticipated that this will encourage more hens further away from the shed.

Oldman saltbush (*Atriplex nummularia*) variety "De Kock" had been planted during 2019 on the ranges of the 10,000 hens/ha sheds and some organic sheds ranges. The saltbush area is fenced off from hens on the 10,000 hens/ha sheds while the saltbush establishes (Figure 3-1-10). When the saltbush reaches at least 1 m tall the area will be opened up for hens to access. The area planted to saltbush starts 5 m from shed out to the first row of trees approximately 30 m away in a 3 x 3 m configuration. It is the zone on the range that normally doesn't grow much. Saltbush is doing very well with the tallest saltbushes already 40 – 50 cm high after 4 months post planting. Those saltbushes closest to the tree line are shorter due to competition effects from trees. In addition, saltbush is responding very well to fertiliser, particularly nitrogen. The saltbush on the organic shed

ranges were planted in twin rows inside the range boundaries and also at right angles from the shed to the outer saltbush boundary. Planting rows were firstly deep ripped, then a planting hole was made with an auger. Fertiliser was also added to the planting hole. Under the dry weather conditions of 2019 the saltbush was watered weekly.

Practices used to manage the range vegetation (e.g. rotation time between different areas of the range, frequency of mowing);

Organic system rotates the range area every 60 weeks. Usually fixed range areas of 1,500hens /ha require regular mowing of the outer range areas (Figure 3-1-8), except during 2019 as there was very little growth due to dry conditions. Fixed range 10,000 hens/ha range areas usually require re-sowing. However, free range accreditation schemes stipulate that only one-third the area at any one time can be fenced off and re-sown. In light of this, the farm may consider placing a 10,000 hens/ha flock under barn production for one production cycle to allow the pasture on the range to be totally renovated.

Figure 3-1-7. Farm 3 Rhodes grass clumps on a range stocked at 10,000 hens/ha.

Figure 3-1-8. Farm 3 naturalised perennial grasses and young trees (planted) on the range stocked at 1,500 hens/ha.

Figure 3-1-9. Fluted mulch pad that collects rain and dew and redirects water to root zone.

Figure 3-1-10. Farm 3 saltbush planted in the 5 to 30 m zone of a 10,000 bird/ha shed. Growth at 3 months old.

3.1.4 Farm 4- temperate (no dry season with a warm summer) climatic zone

Average Annual Rainfall & Rainfall pattern; 1066 mm, uniform rainfall pattern.
Rainfall total for 2019 = 617 mm.

Soil type; Heavy textured clay soils. Soil pH measured in $CaCl_2$ is highly acidic through much of the profile, 3.0 – 4.8 (0 – 60 cm) and 5.6 – 6.0 (60 – 100 cm).

Length of time the farm has been operating; The farm has been running poultry since 1997 and the case study shed is 7 years old.

Range size, range shape, locality of the shed within the range area; the shape of the range is roughly square and subdivided into 4 paddocks. Each subdivided paddock is one hectare.

Orientation of shed; East-West

Shed type (1-sided or 2-sided pop-holes); 2 sided with pop holes on southern and northern sides.

Additional structures (e.g. shade shelters, hay bales) on the range; No shade structures on the 10,000 hen/ha range as there are plenty of trees.

Flock size and flock age; 30,000 Hy-Line Brown, 40 weeks old at the time of the visit (July 2019).

Outdoor stocking density; 10,000 hens/ha.

Percentage of total flock on the range, where on the range and what is the main activity of the hens, weather conditions at time of visit; Approximately 4,000 birds outside. An estimated 300 hens were foraging on the outer extremities of the range area with the majority of the hens dustbathing under trees by the shed. The weather was sunny, 14 – 17^{o}C, light breeze, slightly damp soil.

Plumage condition score and beak shape scores of hens on the range and indoors; Feather condition was not scored on the visit, but the feather condition of those birds seen outside was very good. There was no neck damage, back or tail damage and plumage was smooth.

Ground cover plant species including weed species on the range; Blue couch (Kentucky bluegrass – *Poa pratensis*) was doing well (Figure 3-1-12). This was harvested from other parts on the farm and transplanted on the range area. Initially the couch runners needed to be buried to protect from hens. Sowing Kentucky bluegrass seed was considered but seed is extremely expensive at $300/kg. Turf type grasses can be useful for the range but expensive seed will be an issue on large range areas. Therefore farm management are considering buying a second-hand turf harvester for transplanting their own couch. Pin rush (*Juncus usitatus*) is growing in some places with couch in between (Figure 3-1-11), however pin rush can be destroyed by hens, they can trample through and flatten it to the ground. Kikuyu is growing in some areas on the range, however hens will eventually dig up the runners. Kikuyu is an issue on the farm, as the property also raises cattle. Nitrite poisoning and a fungal disease that infects kikuyu can cause toxicity in cattle. Perennial ryegrass and red clover have been sown on some of the ranges. Although the clover is the first to be picked out by the hens. Lucerne has also been trialled but was not successful. Common weed species on the range are stinging nettle (*Utrica dioica*), marshmallow (*Malva parviflora*), fat hen (*Chenopodium album*), Paddy's Lucerne (*Sida rhombifolia*). The hens do not eat the stinging nettle and they use the Paddy's Lucerne for shelter. Weed control is via mulching, especially weeds such as marshmallow.

Tree type, location on the range, number and age of trees;
At least 10 native tree species which include sheoaks and callistemon were planted 8 years ago. Wattles were originally planted on the range but these were removed due to processionary caterpillars (*Ochrogaster lunifer*) that lived on the wattles. Processionary caterpillars were a major problem due to their noxious hairs that irritated livestock including the hens. The closest group of trees are located 10 – 20m from the shed. Some trees have their roots exposed from hen activity, particularly those growing on steep slope areas. Some trees closest to the shed are dying and this may be due to high nutrient loads. Trees have also been planted on the downside of contour banks.

Practices used to manage the range vegetation (e.g. rotation time between different areas of the range, frequency of mowing); The subdivision of the range into 4 areas enables rotation with one area re-sown and rested at a time. The area requiring renovation is firstly cultivated to level out the surface from dust bathing divots. The overall range is sloping with contour banks. The contour banks have been fenced off from hens. Connecting passageways have been constructed through contour banks to enable hens to move to the lower slope areas of the range. These passage areas have tyres and mesh to protect soil from digging birds and allow water movement.

Figure 3-1-11. Couch grass area with pin rush and trees below contour bank.

Figure 3-1-12. Couch grass on the lower slope of case study Farm 4.

3.2 Guideline package

The guideline package was compiled by Michael Wurst (Rural Solutions SA) and Carolyn de Koning (SARDI). Information within the package is generic and aimed for first time egg farmers with very little or no agricultural experience. Topics covered in the package are outlined in the Table of Contents.

1. Introduction

2. Australian Climate and Soils

- Australian Climatic Zones
- Australian Average Annual Rainfall
- Soil Characteristics

3. Setting-up a New Range

- Categories of Pasture Plants
- Categories Used in the List of Pasture Species and Varieties
- Species/Variety Selection
- Seven Steps to Successful Perennial Pasture Establishment
- Pasture Establishment Costs
- Irrigation
- Drought - Management of Pasture
- Drought – Tree and Shrub Selection
- Fire Protection

4. Regenerating a Current Range

- Techniques to Improve Pasture Composition
- Biosecurity

5. Establishing Trees and Shrubs for Shelter

- Other Shelters
- Shelter Belts for Odour Control
- Shelter Belts for Protection
- Shrub and Tree Species
- Planning to Plant

6. Managing Nutrient Run-off

- Water Run-off
- Interception Banks

7. Poisonous Plants

- What is a Poisonous Plant?
- Egg Contamination
- Bird Health
- List of Poisonous Plants

8. Case Study Farms

Farm 1 – Temperate (Mediterranean) climatic zone

Farm 2 – Temperate (Cool) climatic zone

Farm 3 – Sub tropical (summer dominant rainfall) climatic zone

Farm 4 – Temperate (No dry season with a warm summer) climatic zone

Farm 5 – Planting Saltbush on the Range

9. Glossary

10. Further Reading

11. Useful Websites

The guideline package is to be published separately by Australian Eggs under the title; "Pasture, Tree and Shrub Selection and Management on Australian Free Range Egg Farms."

3.3 Perennials on the range 'Proof of concept'

Information on planting saltbush on the range is presented in the guideline package as case study Farm 5. Results on saltbush survival, ground cover, botanical composition, hen plumage scores, beak shape scores, hen interactions with saltbush and frequency venturing onto the outer range are highlighted in this section. Lucerne was not sown as conditions were too dry. Annual medic (*Medicago spp*.) was considered as an alternative to lucerne for sowing between saltbush rows in 2018 and 2019. It was also too dry to contemplate sowing annual medic.

3-3-1 Saltbush survival

Average annual rainfall for the farm is around 360 mm, with cool wet winters and hot dry summers. Rainfall during 2017 was close to average (355 mm) but during 2018 the area had only received 170 mm and 2019 received 221 mm rainfall. Soils are moderate to highly calcareous gradational clay loams with moderate fertility. Soil pH measured in $CaCl_2$ is 6.6 – 7.0 (0 – 15 cm) and alkalinity increases with depth with 7.1 – 7.5 (15 – 60 cm) and 7.6 - 8.0 (60 – 100 cm).

In 2017 a total of 1,000 seedlings were planted (500 per range) and a further 500 (250 per range) in 2018 to fill in the gaps due to seedling deaths in 2017. In hindsight this was too many seedlings to look after, given conditions at planting were so dry and it meant a lot of follow-up watering. Despite the dry conditions the survival was 41% (shed 1) and 51% (shed 2) for the two range areas in October 2019. Saltbush plants from the 2017 planting were over 1 m tall whereas the saltbush from the 2018 planting were 50 cm tall.

3-3-2 Ground cover and botanical composition

In 2018;

Flock E1 (shed 1) was Hy-line Brown and Flock E2 (shed 2) was Lohmann Brown. Flock size were the same for each shed, nominally 30,000 hens stocked at 10,000 hens/ha. The saltbush rows start 70 m and 50 m from the western end of the sheds (E1 & E2 respectively). Both flocks E1 and E2 had been depopulated by early November 2018. Percentage dry ground coverage (all plants had senesced at time of assessment) on the outer range was measured post flock depopulation on 9/11/2018. Plant identification was not possible due to dry vegetation. Saltbush areas had significantly less ground

coverage compared to control areas (Table 3-3-5). However, saltbush areas were sprayed the previous year on 7/9/2017 (Powermax® Glyphosate 3L/ha) before the first planting of saltbush on 27 to 28/9/2017. Therefore it was likely there would be less ground cover in saltbush areas leading into 2018. Shed 1 /flock E1 had significantly more ground cover than shed 2 /flock E2. This may be due to soil type variations. Differences between saltbush ground cover and the control areas was greater for shed 2 /flock E2. Ground cover percentage increased the greater the distance away from the shed irrespective of saltbush or control treatments (Figure 3-3-13). There were no treatment x distance interactions.

	Flock E1 (Hy-line Brown)	**Flock E2 (Lohmann Brown)**
Saltbush	40.3 [a]	17.8 [a]
Control	45.6 [b]	28.6 [b]
P value (Saltbush v Control)	0.044	< 0.001
Shed effect	42.9	23.0
P value (shed effect)	< 0.001	

Table 3-3-5. Percent ground cover measured on 9/11/2018 for saltbush planted areas and control areas on the outer range of two sheds after flocks depopulated. Different superscript letters in the same column are significant P < 0.05

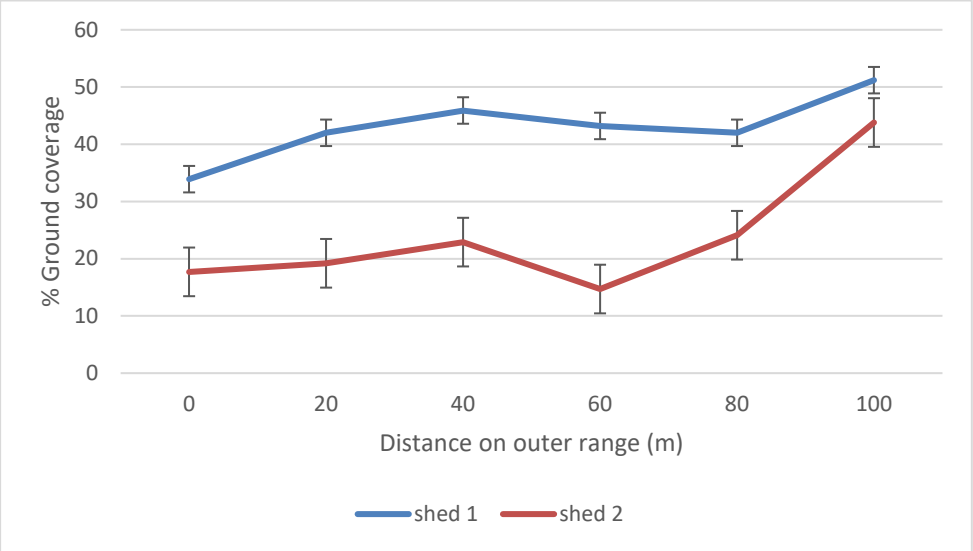

Figure 3-3-13. Percent ground cover irrespective of saltbush and control treatments moving further onto the outer range away from the shed. Shed 1 the outer range begun at 70 m and shed 2 begun at 50 m from the western end of the shed. 0 m represents the start of measurements on the outer range.

Percentage ground cover on the outer range did not change greatly from 0 m to 80 m and was significantly higher at 100 m indicating that hens had been foraging out to at least 150 m for shed 1 and 130 m for shed 2.

In 2019;
Total rainfall received in the region during 2019 was 221 mm, this represents 62% of the average annual rainfall. Over half of the rain fell in May and June (135 mm) while all other months were below average.

Green ground cover and botanical composition were measured on 14/6/2019 and 2/8/2019. Saltbush and control areas had similar levels of green ground cover. However, shed 1 always maintained a higher level of ground cover compared with shed 2. This is partly to do with the younger age of the flock in shed 1 and time of germination for ground cover plants (May). Shed 1 range had a chance to increase ground cover before hens started ranging further than 50 m away from the shed. For example on the 14/6/2019 (Table 3-3-6). The shed 2 flock was older and was actively ranging away from the shed when ground cover plants germinated in May and were trying to establish and grow, hence only 5% cover at 50 m from the shed. Mostly distance from the shed was highly significant for green ground cover. Closest to the shed had less green cover (Table 3-3-6). Green ground cover had increased across both ranges in August due to plant growth when compared with June. Green ground cover had dried off during September, although hens were still visiting the outer range as shown by wildlife cameras.

The main ground cover species growing on the ranges were carpet weed (*Galenia pubescens*), annual *Medicago* species and Ward's weed (*Carrichtera annua*). There were grasses and other broadleaf plants but these were not as abundant. Carpet weed was the most common plant on both ranges, followed by annual *Medicago* species. Carpet weed was found to constitute between 0.5% to 66% of the botanical composition dependant on distance from the shed (P<0.001). At 50 m from the shed it was found at low levels suggesting the hens were actively selecting carpet weed while furtherest on the range it was the most dominant component. The reverse was found for annual *Medicago* species with 46.5% to 2.4% (P<0.001) with more *Medicago* found at 50 m and less moving further away from the shed. *Medicago* would find it difficult to compete with carpet weed on the furtherest sections of the range. Farm management are planning to plough and resow the range areas with desirable pasture plants to reduce carpet weed. Seasonal conditions had not been favourable to attempt sowing pastures.

	Shed 1, flock F1		**Shed 2, flock F2**	
	14/6/2019	**2/8/2019**	**14/6/2019**	**2/8/2019**
Distance from shed (m)	Hen age 40 weeks	Hen age 47 weeks	Hen age 50 weeks	Hen age 57 weeks
50	53.2	73.3 ^{a}	5.1 ^{a}	5.5 ^{a}
70	56.0	84.1 ^{b}	13.6 ^{b}	28.1 ^{b}
90	59.8	79.6 ^{ab}	36.0 ^{c}	43.5 ^{c}
110	55.4	89.1 ^{c}	45.5 ^{d}	57.2 ^{d}
130	52.6	92.4 ^{c}	45.9 ^{d}	59.8 ^{d}
150	54.0	95.0 ^{c}	54.2 ^{e}	62.3 ^{d}
	NS	***	***	***

Table 3-3-6. The effect of distance from the shed on percentage green ground cover on the ranges of two free-range flocks stocked at 10,000 hens/ha in southern Australia. NS = Not significant, * = P < 0.05, ** = P < 0.01 & *** = P < 0.001. Different superscript letters within a column indicate statistical significance at P < 0.05.

3-3-3 Hen plumage scores and beak shape scores

In 2018;

Plumage score and beak score were assessed mid production when the flocks E1 and E2 were 40 weeks and 47 weeks respectively (Table 3-3-7). Plumage damage were similar for range and shed birds for both flocks, but there were differences between bird strains (P< 0.001). Whereby, Lohmann Brown hens had substantially more plumage damage even though they were only 7 weeks older than the Hy-line Brown flock. Beak scores were also different, with Hy-line Brown hens with a lower percentage of acceptable beak shapes. Hy-line Brown hens had a higher proportion of birds with beak score 6 (data not shown).

	Shed 1/ flock E1 (hen age 40 weeks)		**Shed 2/flock E2 (hen age 47 weeks)**	
	Plumage	Beak *	Plumage	Beak *
Range	0.81	86 %	4.10	94 %
Shed	0.86	90 %	4.27	100 %
P value	0.743	-	0.495	-

Table 3-3-7. Plumage score and beak score % for two free-range flocks, shed 1 (Hy-line Brown) and shed 2 (Lohmann Brown) in 2018. *Beak score (percentage of acceptable beak shapes 3 + 4 + 5) based on; Glatz P, Runge G (2017) Managing Fowl Behaviour - A best practice guide to help manage feather pecking and cannibalism in pullet, layer and breeder flocks. Australian Eggs, 148 pages.

In 2019;

Hens found in two zones of the range were scored (flock F1 only); those hens within 50 m of the shed and those hens on the outer range with saltbush (50 m <). Hens foraging on the outer range amongst the saltbush had significantly better feather condition, particularly on the neck, tail and wings (Table 3-3-8). Flock F2 were not scored due to insufficient hen numbers on the outer range.

Zone on range	**Neck**	**Back**	**Base tail**	**Tail**	**Wings**
Within 50 m of shed	1.01	0.08	0.09	0.63	0.13
Greater than 50 m from shed	0.29	0.03	0.03	0.39	0.03
P value	0.000	0.131	0.082	0.002	0.011
Significance	***	NS	NS	**	*

Table 3-3-8. The average plumage score for the neck, back, base tail, tail and wings of hens (57 weeks old) on two zones of the range; within 50 m from the shed and greater than 50 m from the shed (saltbush area). NS = Not significant, * = P < 0.05, ** = P < 0.01 & *** = P < 0.001

There were differences in beak shape scores of hens between the two zones on the range in 2019 (Figure 3-3-14). Hens on the outer range with saltbush had proportionally more beak shape 3 and less beak shape 6.

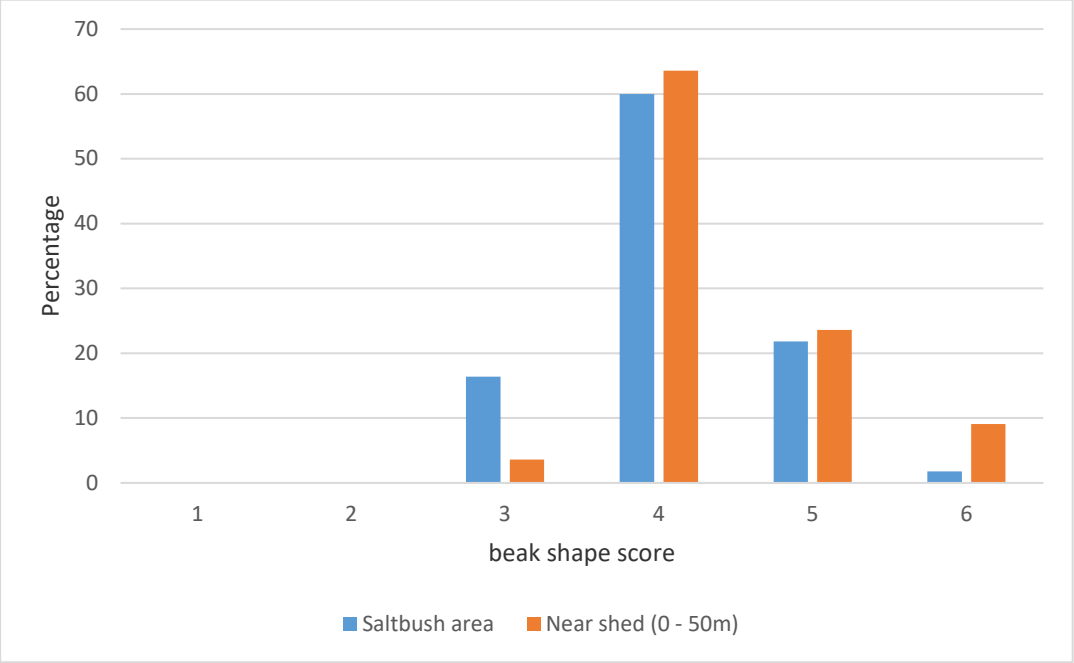

Figure 3-3-14. Percentage hens with beak shape scores from two zones on the range of a free range farm in southern Australia. Scores measured in the 0 – 50 m area near the shed and the saltbush area 50 m < from the shed.

3-3-4 Hen interactions with saltbush and hen frequency visiting the outer range

Hen numbers on the range were counted on 2/8/2019 and 9/10/2019. The highest percentage of the flock outdoors was 34% on the 2/8/2019, with only 1.4% of the flock on the outer range during the visit. The weather was sunny, 12°C with no breeze. Fewer hens were outdoors during the visit on 9/10/2019 with 17% of the flock outside, approximately 100 hens (flock F1) were found on the outer range. The temperature at the time was 20°C, sunny with a ESE breeze at 9km/hr.

A variety of information had been generated from wildlife cameras. Images and video from three of the four cameras was used. One camera had reached storage capacity within nine days of placement, therefore the data from this camera was not included. This was due to excessive activity from hens and crows following a pair of wedgetail eagles attacks on the range of shed 2/flock F2. The optimum temperature for hens ranging was between 17°C to 21°C (Figure 3-3-15). Temperatures 13°C – 17°C and 21°C – 25°C had the next highest frequency level. There was a decrease in the frequency of hens on the range as temperatures increased above 25°C. Correspondingly hen numbers decreased on the range as temperature increased (Figure 3-3-17). It should be noted, during extreme hot weather the popholes were closed so it is unlikely to see hens outdoors when the highest temperature of 41°C was reached during the time cameras were on the ranges. The most popular times of the day for hens to be out ranging away from the shed were between 10am to 11am (shortly after pop holes were opened). Hens had ranged throughout the day but at lower numbers (Figure 3-3-16).

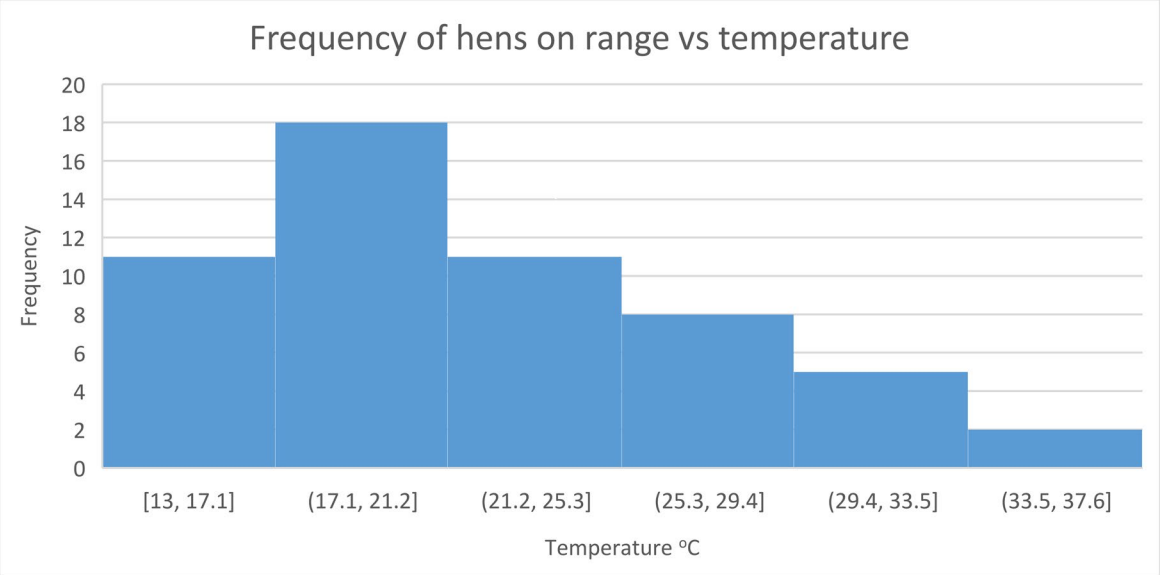

Figure 3-3-15. Frequency of hens found on the outer range (70 - 120 m from the shed) versus temperature. Data from 3 wildlife cameras placed on two ranges of a free range farm from 2 August 2019 – 9 October 2019.

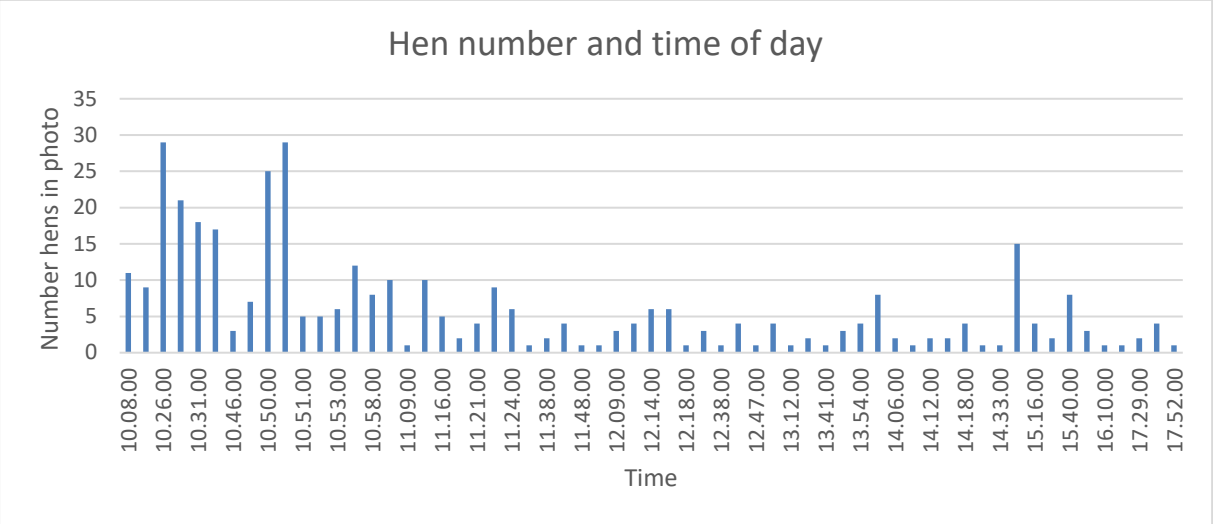

Figure 3-3-16. Time of day and the number of hens in the photo frame. Data from 3 wildlife cameras placed on two ranges of a free range farm from 2 August 2019 – 9 October 2019.

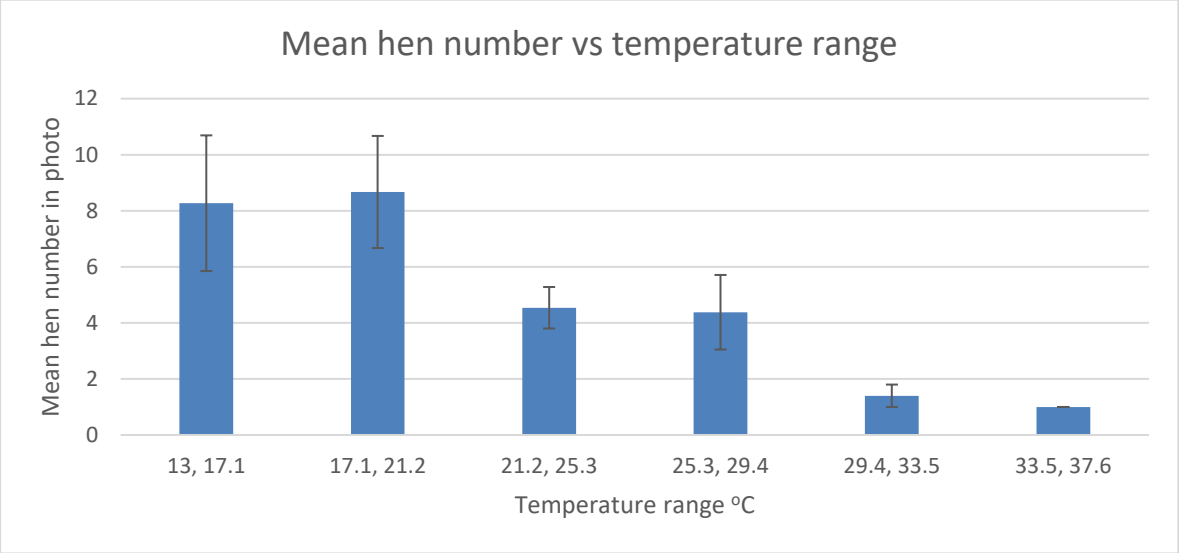

Figure 3-3-17. The relationship between the number of hens photographed on the range (70 – 120 m from the shed) using wildlife cameras and ambient temperature on a free range farm in southern Australia during 2 August to 9 October 2019.

Wind strength influenced the frequency of hen visits and number of hens on the outer range. Calm conditions were the most favoured by hens (Figure 3-3-18), although similar numbers of hens were photographed under breezy conditions when compared to calm conditions (Figure 3-3-19).

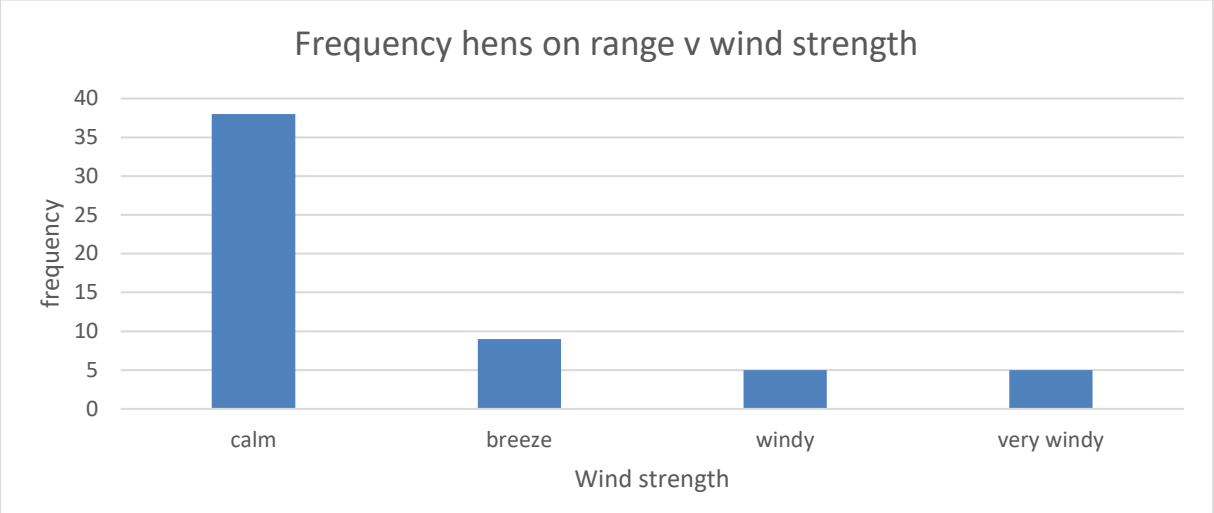

Figure 3-3-18. Frequency of hens found on the outer range area (50 m < from the shed) under increasing wind strength ratings. Calm = 0 km/hr, breeze = <19 km/hr, windy = 20 – 39 km/hr and very windy = 40 – 50 km/hr.

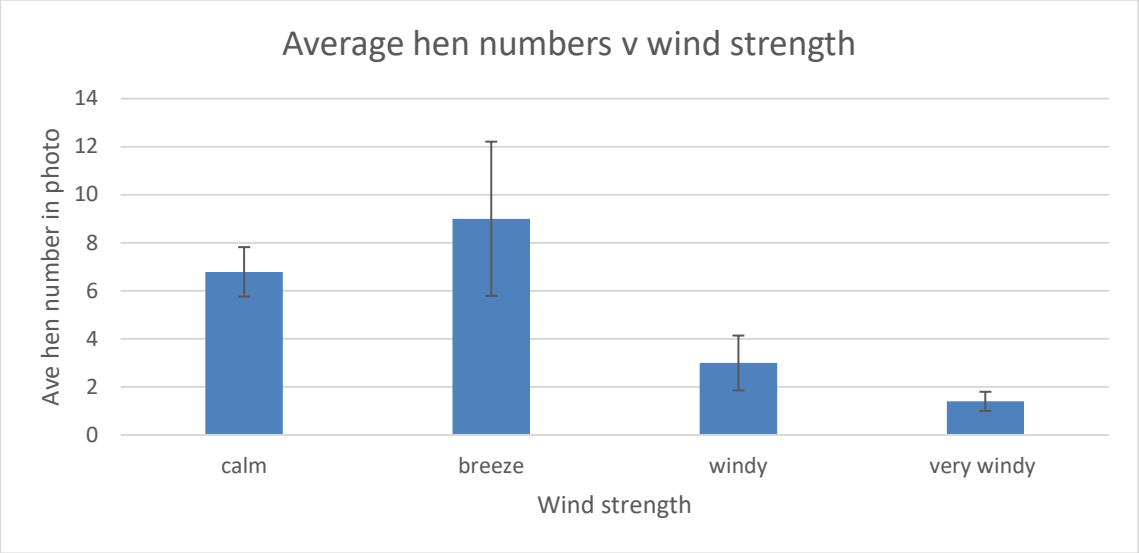

Figure 3-3-19. Average number of hens photographed on the outer range (50 m < from the shed) with increasing wind strength. Calm = 0 km/hr, breeze = <19 km/hr, windy = 20 – 39 km/hr and very windy = 40 – 50 km/hr.

Hens utilised the saltbush for sheltering, dustbathing under and foraging around. Shed 1 also had the native species of small leaf bluebush (*Maireana brevifolia*) growing on the range, hens used the bluebush in a similar manner.

4 Discussion

Impact of drought

All five case study farms had been impacted by drought conditions throughout the duration of the project. Drought conditions were most severe for Farm 3, whereby in 2019 the farm had only received 27% of their average rainfall. As a result of drought, the re-sowing of ranges was being delayed until favourable conditions (except where irrigation was an option) and the regrowth of established range plants was slow.

Perennial plants on the range

Ground cover species

A common feature of the case study farms was the sowing of perennial pasture species for ground cover (Table 4-9). The species chosen were suited to the farm's climatic zone. Perennial legumes were sown across all case study farms, except Farm 5. Farm 5 had the lowest average annual rainfall of all the farms studied, therefore opportunities for sowing perennial legumes such as lucerne were limited. Lucerne was sown on three farms (Farms 1, 2 and 3) across temperate and subtropical zones, demonstrating lucerne's versatility. However, Farm 4 had trialled lucerne but it did not persist. This is highly likely due to very acidic soils on Farm 4, as lucerne does not tolerate high soil acidity and high Aluminium. Lucerne requires a soil pH range of 5.8 – 8 in $CaCl_2$. However, lucerne can be grown dry-land (i.e. Does not require irrigation), as was the situation on Farm 1. Many lucerne varieties are available that have been developed for Australian conditions and seed can be readily purchased. Grazing tolerant Lucerne varieties are now on the market that have low growing /compact crown structures (plant structure where all the growing points are located), this maybe a useful attribute under hen activity (pecking and scratching). A Lucerne stand can persist for 8 - 10 years under livestock systems and can be sown in areas receiving 325 mm to 800 mm + annual rainfall.

Red clover was sown on Farm 2 and 4. Yet, both farms found it was one of the first plant species targeted by hens. A similar species, white clover was strongly targeted by hens as demonstrated in the study by Breitsameter *et al* (2013) whereby white clover had 90% removal of aboveground biomass after 15 hours stocking with layer hens.

The range of Farm 1 and Farm 5 (saltbush trial) located in the temperate (Mediterranean) zone was dominated by annual species during the winter and spring. The annual species would die off in late spring, leaving lucerne as the main green plant on the range of Farm 1. Even though Farm 5 had not sown perennial pastures, there were native perennial plant species present on the range. They included several native grass species and other small shrubs such as pop saltbush (*Atriplex spongiosa*) and small leaf bluebush (*Maireana brevifolia*). Similarly, Dal Basco *et al.* 2014 found it was usual for Mediterranean free range farms in Italy to have a combination of annuals and perennials.

Perennial ryegrass was sown in the temperate (cool – Farm 2) and temperate (no dry season with warm summers – Farm 4). Both farms would normally receive high rainfall to support perennial ryegrass. In addition, Farm 2 had also sown biennial ryegrass as it establishes and grows fast. Kentucky bluegrass was performing well on the range of Farm 3, but it did require protection initially from hens to allow it to establish. The main concern with Kentucky bluegrass was expensive seed. Perennial grasses were not sown on the farms located in the temperate (Mediterranean) zone, this possibly is due to both farms being located in broad-acre cereal/ livestock production areas where perennial grasses are not traditionally sown. Also, both Farm 1 and 5 do not have the

average annual rainfall to support perennial ryegrass. In the subtropical zone (Farm 3) Rhodes grass was grown on the range and it is also utilised on free range farms in some regions of Western Australia. Rhodes grass is mostly resilient to hens, except the fresh regrowth following mowing is susceptible to foraging hens. Farm 3 also had various native perennial grass species growing on the ranges. Kikuyu was grown on two farms, but not found suitable as it was not resilient to hens and needed good rainfall or irrigation to maintain green growth.

Percentage ground cover was strongly influenced by the distance from the shed. Whereby, percentage ground cover increased moving away from the shed with the range stocked at 1,500 hens/ha (Farm 1). This had also occurred on Farm 5 with an outdoor stocking density of 10,000 hens/ha where hens were actively utilising the range out to 150 m from the shed. The range was large (4ha) to accommodate a flock of 30,000 hens. Furthermore, botanical composition varied dependant on the distance from the shed. This was a reflection of hen activity and numbers. Weed species were common closest to the shed.

Farm	Climatic zone	Average annual rainfall mm	Sown perennial pasture species (Legumes & grasses)	Unsown background species (including weeds, w; native, n; pasture, p)
1	Temperate – Mediterranean	470	-Lucerne	-Lagoon saltbush, n -Annual ryegrass, w/p -Wire weed, w -Marshmallow, w -Shepherds purse, w
2	Temperate - Cool	610	-Lucerne -Red clover -White clover -Perennial ryegrass -Biennial ryegrass	-Subclover, p -Prairie grass, p -Cocksfoot, p -Wireweed, w -Marshmallow, w
3	Subtropical – Summer dominant rainfall	626	-Lucerne -Rhodes grass -Creeping bluegrass -Kikuyu	-Native grasses, n -Feathertop Rhodes grass, w -African lovegrass, w
4	Temperate – No dry season warm summer	1066	-Red clover -Perennial ryegrass -Kentucky bluegrass -Kikuyu	-Paddy's lucerne, w -Marshmallow, w -Fathen, w -Stinging nettle, w -Pinrush, n
5	Temperate - Mediterranean	360	-Perennials not sown	-Annual medic, p -Carpet weed, w -Ward's weed, w -Native grasses, n -Small leaf bluebush, n -Pop saltbush, n -Barley grass, w

Table 4-9. Comparison of perennial pasture species sown on the ranges of the free range case study farms along with unsown species (including weeds, pasture plants and native plants) found growing on the ranges.

Many of the species sown and naturally occurring (e.g. weeds) on the range of the case study farms were the same species found during the free range survey (Singh *etal.* 2015).

Trees/shrubs

Native species of trees and shrubs were planted on all farms and locally adapted species were sourced from their region. Wattles were common and planted on three farms. The appeal of wattles was their rapid growth rate as seen on Farm 2, the wattles had reached 3 m tall in two years. However, two farms had chosen not to plant wattles, one farm due to weediness concerns for nearby bushland and the other farm had problems with processionary caterpillars that lived on the wattles and caused irritation to livestock and hens. Various tree planting configurations were also trialled on the farms. Rows of trees leading out from the shed to the outer range areas was typical. One farm planted circular groves of wattles, these were popular with the hens and were observed to be used in preference to the constructed shelters that were placed adjacent to the shed. Farms had assigned dedicated staff to look after trees and shrubs. Newly planted trees were being watered frequently (weekly to fortnightly) to assist their survival through drought conditions. Oldman saltbush had revealed under drought conditions how tough it can be. Hence, free range farms located in low rainfall zones and/or erratic rainfall have the option of Oldman saltbush (de Koning *etal.* 2019). However, Oldman saltbush is not tolerant of acid soils therefore Tagasaste and wattles could be the equivalent fast growing shrubs to use in acidic soils at other localities in Australia. Shrubs and trees were instrumental in attracting hens onto the range as such they are an important asset for free range farms.

Plumage score and beak scores differences between inside and outside hens

Ranging hens had better plumage scores than those hens in the shed. This was found for both outdoor stocking densities (1,500 and 10,000 hens/ha). Results are similar to those obtained by de Koning *etal.* (2019). In addition, the hens further away from the shed had better plumage condition than those staying within 50 m from the shed. These results support the findings of Chielo *et al*. 2016, they had found those hens furthest from the shed had the best feather condition. Furthermore, increased shade on the range provided by growing trees and shrubs may have contributed to better plumage (Bright etal. 2011). For example, the second flock on Farm 2 had exceptional plumage compared to the previous flock. The circular wattle groves on this farm had grown substantially providing increased shade for the second flock.

Beak shape scores also differed between inside hens compared to ranging hens. The total percentage of acceptable beak shapes was lower for ranging hens, with a greater proportion of hens with beak shape score 6 found outdoors ($P = 0.022$) and a greater proportion of hens with beak shape 4 found in the shed ($P = 0.04$, Table 4-10). It is postulated that hens with beak shape 6 are avoiding being feather pecked by going outside, they are also less capable of damaging other hens by pecking due to their larger lower beak step. This may contribute to the better plumage condition of hens outside. Conversely, more hens with beak shape 4 were found indoors (47.1 %) and this may contribute to increased plumage damage of hens found in the shed. The near even upper and lower beak lengths of beak shape 4 may enable those hens to feather peck. In addition, hens foraging greater than 50 m from the shed had propotionally less unfavourable beak shape score 6 and more beak shape 3. Possibly hens with the unfavourable beak shape 6 are less likely to find foraging away from the shed easy due to their large lower beak step. Whereas those hens with beak shape 3 would find it easier to forage due to even top and bottom beak lengths and are prepared to go to where ground vegetation and saltbush can be found on the outer range. Although this result is interesting it is only based on one flock at one point in time. Therefore, it would need further investigation using more flocks to determine whether beak shape score influences the ability of hens to forage further away from the shed (i.e. hens with a lower beak step less than 5 mm are better equipped to forage on the range away from the shed).

Beak shape score	Range	Shed	P value
3	13.2 % (3.63 ± 0.93)	15.6 % (3.95 ± 0.78)	0.797
4	40.2 % (6.34 ± 0.12)	47.1 % (6.86 ± 0.19)	0.040
5	29.6 % (5.44 ± 0.57)	26.9 % (5.19 ± 0.47)	0.740
6	9.2 % (3.04 ± 0.22)	4.8 % (2.19 ± 0.24)	0.022

Table 4-10. The mean beak shape scores from three farms (Farms 1, 2 & 5) and five flocks (all Hy-line brown) for hens found on the range versus hens in the shed. In brackets are the transformed square root means and standard errors. Back-transformed percentage means presented outside brackets. Note, no beak shape 1 and 2 were recorded.

Hens utilising the outer range

The hypothesis of sowing perennials on the outer range (50m < from the shed) to attract more hens out to use this area of the range could not be proven. Due to dry conditions the interrows between the saltbush rows could not be sown with lucerne or annual medic species. The inclusion of lucerne or annual medic may have added to the attractiveness of the range. However, the increase in ground cover moving away from the shed was evidence of hens utilising the range out to at least 150 m from the shed and video showed hens followed the saltbush rows. In addition, temperature and wind strength were strong influences on whether hens visited the outer range. Temperatures above 25^{o}C reduced the number of hens and frequency of hen visits while calm conditions without breeze or wind were most prefered. Time of day was also shown to be influential with the greatest number of hens on the outer range shortly after popholes had opened in the morning.

The wildlife cameras had pros and cons. They cannot be used to count total hen numbers found on the outer range and strong winds caused shrub foilage to move which resulted in false positives. There is a compromise between camera sensitivity settings; set too high would result in more false positives and set too low may not trigger the camera when birds/animals are present. Despite the cons there is useful information to be gained from the use of wildlife cameras on the range. For example, the frequency of hens visiting the outer range, along with the date, time of day and temperature. Video footage can also be used to determine whether or not it is windy and what the hens are doing. Furthermore, photos and videos were used to identify other bird species (data not shown) on the range along with the weather conditions while hens were outdoors such as sun, cloud and rain.

Figure 4-20. Saltbush on the range being utilised by hens despite annual ground cover species dying-off in spring. The area was 70 to 120 m away from the shed.

5 Conclusions

- Perennial pasture plants are very important for free range layer farms, with both perennial grasses and perennial legumes utilized. When annual species had died off for the season, perennials provided some green ground coverage, this was most evident on those farms in the temperate (Mediterranean) zone during summer.

- It was difficult to achieve even usage by hens across the range. Hens utilize the areas closest to the shed more often. In addition, temperature and wind strength are strong modifiers of the hens willingness to go further afield. Hens are less likely to venture to the outer range if temperatures are above 25^{o}C and it is windy. Ground cover is denuded close to the shed with progressively more coverage moving further from the shed.

- Botanical composition of the ground cover species will change according to the distance from the shed. This is a direct influence of the level of hen activity; with more activity and hen numbers closest to the shed and less activity and hen numbers furthest from the shed. Weed species tend to be present closest to the shed.

- Drier climates and/or drought conditions limit the opportunities for free range farms to re-sow ground cover on the range and plant trees/ shrubs. However, free range farms in drier climatic zones can benefit from growing shrubs like Oldman saltbush.

- Case study farms were actively re-sowing ranges when climatic conditions permitted and approached the task with agronomic consideration for correcting soil issues such as heavy clays and acidic soils. (e.g. gypsum and lime respectively).

- Tree and shrubs played a vital role on the range providing shade, shelter and dustbathing sites. All farms were actively planting trees and shrubs with hardy local species used. Furthermore, trees needed protection around the root zone from hen activity especially ranges stocked at 10,000 hens/ha.

- Ranging hens from both outdoor stocking densities of 1,500 and 10,000 hens/ha had better plumage condition. Distribution of beak shape scores of outdoor hens were different to indoor hens. Further research into the ability of hens to range based on their beak shape score is warranted.

- The main output from this project is the guideline package, which consists of general agronomic information on how and what to plant. Case study farms added significantly to the package with their experience and knowledge on the plants they used on the range.

6 Appendix

(Paper published in the Proceedings of the Australian Poultry Science Symposium, 2020)

DROUGHT IMPACTS ON PLANT GROUND COVER ON A FREE RANGE EGG FARM

C.T. DE KONING[1]

Summary

Plant ground cover changes were studied on the range of a free range layer flock located in the Mediterranean zone of Australia. Drought conditions were experienced during the study and high-lighted the difficulty for farms to maintain green ground cover during adverse dry conditions. Hen activity stocked at 1500 birds/ha had significantly influenced percentage ground cover, pasture height and botanical composition at flock age 32 weeks compared with 65 weeks. Significant effects were also shown for distance from the shed for ground cover, pasture height and botanical composition. Furthermore, flock age x distance from the shed were highly significant for the percentage lucerne (*Medicago sativa*) and lagoon saltbush (*Atriplex suberecta*) growing on the range.

I. INTRODUCTION

Maintaining vegetation on free range farms with fixed ranges is a significant issue (Singh et al., 2017). Nonetheless, free range accreditation programs stipulate palatable vegetation to be available on the range at all times (RSPCA 2015). This is more problematic to achieve during dry seasonal conditions and drought, which are common features of the Australian climate.

II. METHOD

The plant ground cover of a free range farm located in the temperate (Mediterranean) climatic zone of Australia was studied during the drought year of 2018. The long-term average annual rainfall for the area is 470 mm (winter dominant rainfall pattern) however, during 2018 the locality only received 250 mm. Lucerne (*Medicago sativa*) is the main plant sown on the ranges of the farm. The shed (15 x 50 m) and range area (3.8 ha) of the case study flock was established in 2014 and had four previous flocks. Subdivided range areas allow for rotation and resting of pasture every 12 months. Flock size was 5000 Hy-line Brown hens (Infra-red beak treated at hatchery) stocked at 1500/ha. Pasture measurements of percentage green ground cover (visual score 0 to 100%), pasture height (cm) and botanical composition (dry weight rank method converted to percentage, Mannetje and Haydock 1963) were made at 10 m, 20 m and 40 m from the shed along four transects (2 transects each side of shed). At each distance (10, 20 and 40 m), 10 quadrats (50 x 50 cm) were assessed. Hens were 32 and 65 weeks of age at the time of pasture measurements (May 2018 and December 2018 respectively). Square root transformation was used for percentage data and Log_{10} for pasture height data. Results were analysed using ANOVA with flock age and distance from the shed as main factors and the interaction flock age x distance.

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III. RESULTS

Distance from the shed was significant for all variates measured (Table 1). Ground cover at 10 and 20 m was similar and increased significantly at 40 m. Pasture height was taller moving further away from the shed. Lagoon saltbush was most commonly found closest to the shed, whereas the opposite was shown for lucerne. Weeds (mostly wire weed – *Polygonum aviculare*) grew predominantly at 10 and 20 m from the shed. Age of flock was also significant for all variates (Table 2). Percentage ground cover, pasture height and percentage lagoon saltbush had all reduced when the flock was 65 weeks old. The reverse occurred for percentage lucerne and weeds, with proportionally more lucerne and weeds at flock age 65 weeks.

Table 1 – Main factor effect of distance from the shed (10, 20 and 40 m) on % ground cover, pasture height, % lagoon saltbush, % Lucerne and % weeds on an egg farm in southern Australia during 2018.

Distance from shed (m)	Ground cover (%)	Pasture height (cm)	Lagoon saltbush (%)	Lucerne (%)	Weeds (%)
10	9.6 (3.10)	5.0 (0.70)	93.1 (9.65)	0.7 (0.83)	1.8 (1.34)
20	9.8 (3.13)	6.9 (0.84)	16.2 (4.03)	42.9 (6.55)	0.9 (0.95)
40	17.8 (4.22)	18.9 (1.28)	0.5 (0.71)	100.0 (10.00)	0.5 (0.71)
LSD $_{5\%}$	0.32	0.06	0.70	0.33	0.37
P value	< 0.001	< 0.001	< 0.001	< 0.001	0.003

Square root transformation was used for % data and Log_{10} for pasture height data. Back-transformed means shown in table with corresponding transformed means shown in brackets. The value for the $LSD_{5\%}$ is based on the transformed data.

Table 2 – Main factor effect of flock age (32 weeks = May 2018 and 65 weeks = December 2018) on % ground cover, pasture height, % lagoon saltbush, % lucerne and % weeds on an egg farm in southern Australia during 2018.

Flock age (weeks)	Ground cover (%)	Pasture height (cm)	Lagoon saltbush (%)	Lucerne (%)	Weeds (%)
32	14.8 (3.84)	12.3 (1.09)	32.1 (5.67)	24.0 (4.90)	0.6 (0.80)
65	9.8 (3.12)	6.1 (0.78)	15.4 (3.92)	45.0 (6.71)	1.43 (1.20)
LSD $_{5\%}$	0.26	0.05	0.54	0.27	0.30
P value	< 0.001	< 0.001	< 0.001	< 0.001	0.010

Square root transformation was used for % data and Log_{10} for pasture height data. Back-transformed means shown in table with corresponding transformed means shown in brackets. The value for the $LSD_{5\%}$ is based on the transformed data.

The only interactions of flock age x distance were for percentage lagoon saltbush and lucerne (Table 3). When the flock age was 32 weeks, lagoon saltbush was common at 20 m. By flock age 65 weeks the proportion of lagoon saltbush at 20 m had significantly reduced. Conversely, the proportion of lucerne had increased at 20 m. Lucerne remained dominant at 40 m from the shed at both flock ages. The range area reported in this paper will be examined a second year (rest phase in 2019) and the range area rested in 2018 will be assessed with the new flock during 2019.

Table 3 – Interaction effect of flock age x distance from the shed on % lagoon saltbush and % lucerne on an egg farm in southern Australia during 2018.

	Lagoon saltbush (%)		Lucerne (%)	
Distance from shed (m)	Flock age		Flock age	
	32 weeks	65 weeks	32 weeks	65 weeks
10	95.6 (9.78)	90.6 (9.52)	0.6 (0.77)	0.8 (0.90)
20	42.6 (6.53)	2.3 (1.53)	15.3 (3.91)	84.6 (9.20)
40	0.5 (0.71)	0.5 (0.71)	100.0 (10.00)	100.0 (10.00)
LSD $_{5\%}$	0.94		0.47	
P value	0.001		< 0.001	

Square root transformation was used for % data. Back-transformed means shown in table with corresponding transformed means shown in brackets. The value for the LSD $_{5\%}$ is based on the transformed data.

IV. CONCLUSION

Hen activity at 1500 hens/ha resulted in plant species variations, ground cover decreases and pasture height reduction across the range. Green ground cover was not extensive during the drought with lucerne and lagoon saltbush providing the majority of green cover. Hens had to travel further for green pick as early summer progressed, with lucerne still available at 40 m. Under drought conditions the provision of green palatable vegetation available on the range at all times would be difficult to maintain at high levels of ground coverage.

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Plain English Summary

Project Title:	Resilient plants to entice hens outdoors on free range farms
Australian Eggs Limited Project No	1HS801SA
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Objectives	The main objective is to increase hen welfare by enticing more hens outdoors on fixed free range farms through resilient ground cover and trees.
Background	Plants (ground cover and trees) grown on free range layer farms provide a vital role by enriching the outdoor range and creating an attractive area for hens to go outdoors and explore. Although, specific information on what to grow and how to go about sowing pastures and planting trees/shrubs is not easy to find for free range egg farmers. Material is spread across many and varied sources. Therefore, the project set out to consolidate agronomic information on how and what to plant while also taking into consideration the main climatic zones of Australia.
Research	The project had three components: 1. Case study farms to see how farms establish and maintain vegetation on the range; 2. Development of a guideline package on what and how to plant a range; 3. The planting of perennials to enhance the outer range areas to increase utilisation by hens. Information generated from components 1 and 3 were incorporated into the guideline package.
Outcomes	A guideline package was developed, title “Pasture, Tree and Shrub Selection and Management on Australian Free Range Egg Farms.” Incorporated within the package are the experiences and knowledge from the case study farms, all of which were impacted by drought at the time of the study.
Implications	The dry conditions during the project highlighted the importance of perennial ground cover plants and the utilization of trees and shrubs on the range.
Key Words	Perennial plants, ground cover, plumage score, beak shape scores, Oldman saltbush, lucerne and wattles
Publications	de Koning, C. T. (2020) Drought impacts on plant ground cover on a free range egg farm. Australian Poultry Science Symposium, 31, 30.