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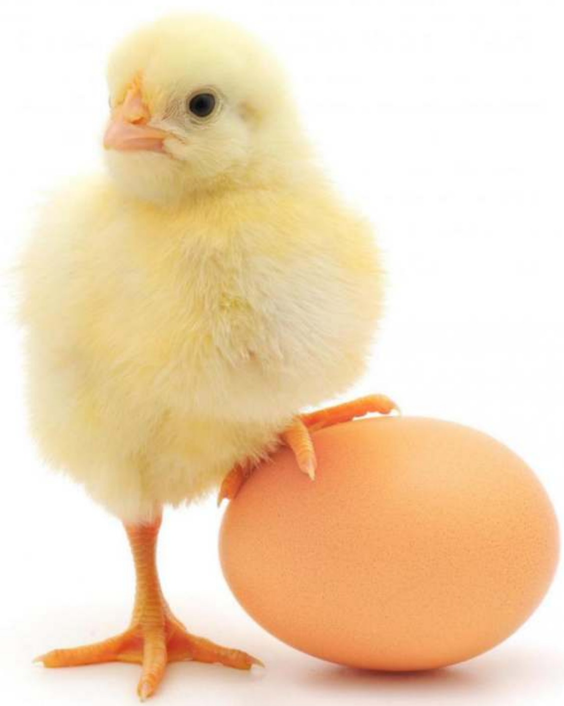

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Integrating Poultry into a Crop and Pasture Farming System

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Abstract: Small scale operations in which poultry forage freely around farms is widespread on rural properties. In Australia grain farmers, market gardeners and graziers integrate poultry into their farming system. In this system, birds are unrestricted in their movements except that they are usually locked in sheds at night for protection from predators. Consumers pay a premium for eggs and chicken meat on the grounds of enhanced welfare of birds in this system. Eggs are perceived as having superior taste and nutritional properties. The purpose of this experiment was to determine the impact of poultry integrated into a pasture and crop rotation system. The pasture availability, insects, weeds and soil fertility were measured before and after grazing by poultry. Sheep were used as a comparison in the experiment. Laying hens stocked at 110/ha (compared to sheep-stocking density 12/ha) were allowed to forage a medic pasture in a crop and pasture rotation system during summer in a Mediterranean environment. The egg production of layers (Hyline Brown) in the free-range system was lower than the standard performance expected in a cage system. Rate of lay from 18-40 weeks was 79% vs 93% (cage standard). The mortality of free-range birds was higher than the cage standard (9.1 vs 1.2%). The reduction of performance of birds relative to the standard was expected considering the heat wave conditions experienced during the experiment. Sheep were very effective in grazing the wire seed, which contaminated the paddocks whereas poultry avoided this weed. In contrast, the number of unidentified weeds in the sheep paddocks was greater than the poultry paddock. This raises the possibility that sheep and poultry could be grazed together in some circumstances, to provide a method for reducing weed build up. Sheep could be used to graze out weeds they prefer and poultry to consume weed seeds and insects that sheep avoid. Soil fertility was not different between the sheep and poultry paddocks. The yield of wheat from poultry paddocks in the subsequent crop was 1.25 tonne/ha versus 1.43 tonnes/ha from sheep paddocks.

Key words: Poultry, sheep, grazing, farming systems

Introduction

Currently, farmers are using a range of chemicals to control weeds, pest and diseases and improve soil fertility. This has resulted in resistance of weeds, pests and diseases, and the contamination of farm products, which is a concern for consumers. The grain industry is recognizing the need to establish a clean green cost-effective weed, pest and disease control program to improve farming profitability and to meet the growing market for chemical free products. Integrating poultry into a traditional crop and pasture rotation system may be one way to control weeds, diseases and improve soil fertility in cropping areas. Under natural conditions, a bird's diet comprises seeds, fruits, herbage and invertebrates and could partly achieve a reduction in problem insects and weed seeds (Tadelle and Ogle, 2000; Lomu *et al*., 2004). Poultry can also clean up the grain spilt from headers during the harvest. In addition, consumers are also beginning to demand products from free-range animal production systems. Surveys of public attitudes indicate that free-range is given the highest rating as an animal production system. The maximum stocking density for free-range egg farms allowed by the Code of Practice in Australia is 1500 birds/ha but build up of nutrients in the soil is not sustainable even at a stocking density of 370 birds/ha (Redding, 2002). This experiment was conducted to determine the performance of poultry (110 birds/ha) integrated into a crop and pasture farming system and subsequent effects on herbage availability, weeds, pests and soil fertility.

Materials and Methods

The rationale for the trial was to determine if poultry could be used to graze the surplus forage in a pasture and cropping rotation on the Roseworthy Campus farm. Birds and sheep foraged on a medic pastures (late stage of the pasture growing season) from 20/12/2000 to 3/5/2001.

Paddocks: A 4 ha paddock located at Roseworthy campus, the University of Adelaide was used for this experiment. Medic pastures were established in May 2000. The experiment commenced in December 2000.

Poultry facility: An eco-shelter (3m x 3m) was built in the centre of a 4 ha paddock. The Eco-shelter had four internal pens of equal size each capable of housing 55 hens (18 weeks of age, Hyline Brown). The paddock was fenced into 8 plots with 0.5 ha/plot. Poultry grazed in 4 plots, and sheep (6 Merino wethers/plot) grazed in the other 4 plots. Throughout the grazing trial, hens were fed twice daily. Half of the ration (55 g/bird) was fed in the morning and the other half (55 g/bird) in the evening. Hens were locked in the shelter over night.

Cropping: After the poultry and sheep had grazed in the paddocks wheat was sown in May 2001 and yield was determined.

Measurements:

Sampling (soil and forage): Each paddock was divided into 3 zones using fence posts as the marker. For sampling forage and soil, a random number of steps were stepped out from the markers and a quadrat (0.1 m^2) placed on the ground. All forage materials above ground level in the quadrat were cut with scissors and collected. Four samples were taken in each zone and placed in labeled brown paper bags. In each zone, an enclosure (0.6m x 0.6m) was set up to exclude birds foraging and was used as the control zone. Forage samples were cleaned by removing dirt and faeces, then weighed and dried at 80°C in an oven to determine total herbage weight or dry matter weight. Samples were obtained before and after grazing by poultry and sheep.

Categories: Each weighed sample was separated into crops, pasture, weeds, seeds, snails, pods and rubbish (dirt, faeces and stone) and then weighed. The classification used was as follows;

1. Pasture: herbage plants and weeds.
2. Crops: seed, broadleaf and narrow leaf weeds.
3. Weed: legumes and weeds.
4. Grains: a 1 kg sample of wheat was screened with a 2 mm rotary screen and small grain (%), ryegrass (%), other weeds identified including Salvation Jane, radish, brome and mustard (%).
5. Insect: adult/pupal/larvae, mites, beetles, bugs, flies, cockroaches and ants.

During the harvest, crop yield was measured by harvesting, cleaning and weighing the total seed yield from all paddocks. The yield was calculated as tonnes/ha.

Production: Over the period 18-40 weeks for laying hens, egg production and mortality were recorded daily. Live weight was measured every four weeks and egg weight was determined by weighing eggs on 3 consecutive days every four weeks.

Chemical composition of herbage: One-third of each herbage sample from four samples was combined and milled in a Makla grinder with a 1 mm sieve for dry matter determination and chemical analyses. Dry matter (DM) was determined by drying samples for 2 h in an oven at 105°C. Ash was determined in a muffle furnace at 550°C for 6 h. Organic matter (OM) was calculated by the difference between DM and ash (Harris, 1984). Crude protein (CP) was determined by using Leco 2000 (Anonymous, 1994).

Soil pH (in water and in 0.01M CaCl): A weighed amount (20.0g) of air-dried soil (sieved < 20mm) was placed into 70ml Sarsdet vials. Fifty (50) ml of deionized water was added and tube was shaken for one h end-over-end. The sample was allowed to settle on the bench for 20 min. The pH was recorded. Following the pH reading in water, 2.5ml 0.21 M $CaCl_2$ solution was placed into each vial, to obtain a 0.01M $CaCl_2$ solution. This solution was shaken for 15 min, then allowed to settle for 20-30 min. The pH was recorded.

Nitrate_N/Ammonia_N: Twenty (20.0) g air-dry soil (<2mm) was placed into a 250 ml plastic extraction bottle and 100ml 2M KCl extracting solution was added. The solution was mechanically shaken end-over-end at 25°C for 1 hour. Then soil extracts were allowed to clear and a known aliquot filtered (Whatman No.42) for analysis.

Nitrate and Ammonia: To determine the mineral-N (Nitrate_N and Ammonia_N) fractions in soil extracts, a dual channel Perstop Analytical Alpkem Auto-Analyser was used. This system simultaneously measures NH_4^+-N and NO_3^--N/NO_2^--N by automated colorimetric procedures. The NO_3^--N + NO_2^--N was measured by the reduction of nitrate to nitrite using cadmium metal in the form of an Open Tubular Cadmium Reactor and the subsequent colorimetric determination of total nitrite nitrogen utilized a modification of the Griess-Illosvay reaction. The determination of NH_4^+-N was obtained by using a modification of the Berthelot Indophenol reaction by replacing hypochlorite with Dichloroisocyanuric acid (DCIC).

Experimental design and statistical analysis: The experiment was a randomized block design. Animals were the main treatment factors. The treatment effects were assessed with ANOVA in Systat software (Wilkinson, 1996). Bonferroni's post hoc was used to separate means only if significant main effects were detected by analysis of variance. Bonferroni's post hoc test is a multiple comparison test based on Student's t statistics and adjusts the observed significance level when multiple comparisons are made. The main factors in the experiment examined were animals, date of sampling, zone and interactions.

Results

Performance of hens: The production performance of hens under the free-range system was compared with the production specifications published by the Hyline company for their brown egg hen strain housed in cages. The free-range hens showed a higher level of mortality (mainly from culling of bullied hens) and lower rates of lay, smaller egg weight and body weight over the period 18-40 weeks (Table 1).

Table 1: Production performance of free-range birds compared to standard strain over 18-40 weeks

	Treatment	
	Free-range	Standard
Mortality and culls (%)	9.1	1.2
Rate of lay (%) (22 weeks)	72	75
Rate of lay (%) (30 weeks)	89	94
Rate of lay (%) (40 weeks)	79	93
Egg weight (g) (40 weeks)	57.2	63.9
Live weight (kg) (40 weeks)	1.93	2.17

The effects on herbage availability, weeds, pests and soil fertility of integrating poultry and sheep into a crop and pasture system

Effects on herbage availability, botanical composition and nutrient availability: There were no significant differences in total biomass, herbage availability, herbage nutrient availability, medic pods and other herbage in medic paddocks before being grazed by poultry and sheep. However, after 5 months of grazing, the parameters were significantly different in medic paddocks grazed by poultry compared to the paddocks grazed by sheep. Sheep had a greater effect on those parameters (Table 2) compared to poultry. Poultry ingested herbage during this period. Nevertheless less herbage was available in the paddocks after grazing (490.6 air dry g/m^2 basis) compared to before grazing (585.0 air dry g/m^2 basis).

Effects on weed numbers and insect numbers: After 5 months of grazing, there was no difference in the number of snails (3.8 vs 1.5/0.1m^2) between paddocks grazed by sheep and poultry. After full germination, there was no difference in number of grass seedling between sheep and poultry paddocks. There was no wire weed and potato weed in the sheep paddocks, but some were recorded in the poultry paddocks. There were more unidentified weeds in the sheep paddock than in the poultry paddocks (16 vs 5/m^2), although the sheep paddock overall had fewer weeds than the poultry paddocks. Very few insects were found in sheep and chicken paddocks (Table 3).

Effects on soil fertility: There was no significant difference in soil nitrate-N, ammonia-N, pH in medic paddocks before or after grazing by poultry and sheep. Nitrate-N increased after grazing in both poultry and sheep paddocks (Table 4).

Discussion

Hen performance: The reduction in performance of poultry compared to the benchmark was expected considering the heat wave conditions experienced and the reduction in natural daylight hours after the summer solstice. During the summer of 2000/2001, South Australia had its hottest summer in a century. The maximum temperature recorded in the shelter was 47°C. Overall, there were 17 days when the temperature exceeded 37°C in the shelter. Marsden and Morris (1987) reported that the feed intake declines steeply as the ambient temperature approaches bird body temperature. As temperature increases, egg weight and shell thickness are reduced (Payne, 1966; Mowbray and Sykes, 1971; Warren and Schnepel, 1940) due to a reduction in energy and protein intake (Emmans, 1974; Cowan and Michie 1977). A different result was reported by Mowbray and Sykes (1971), who found that egg production could be maintained at the same rate as that achieved by normally housed control birds when the air temperature was kept constant at 30°C, or cycled from 30°C to 18°C or from 35°C to 13°C (10 h at the higher temperature in each case). This difference in production response of birds was due to controlled environmental conditions used by Mowbray and Sykes (1971). During the hot weather hens remained within the shelter or within the immediate surrounds and were able to keep cool by dust bathing in the litter or in the soil, where water had been sprayed. The shelter was located on a small hill in the paddock and there was always a breeze that ventilated the birds in the shelter. However, the production performance by free-range hens in this study is similar to the data reported by Barnett (1999) on the experience with free-range egg production in Europe.

Egg weight and body weights were lower than the benchmark. This was because hens were very active in the free-range environment. Hens were very active in the paddock when light drizzly rain was falling. It was apparent that hens were attracted to the insects, which were more active during this period. Hens foraged mainly within 30-40 m from the shelter but would also forage further out into the paddock especially when attendants were present.

Table 2: Herbage availability, botanical composition and nutrient availability in the medic paddock grazed by poultry and sheep

Animal	Total biomass (air dry g/m^2)	Herbage only (g/m^2)	Medic pods (No./0.1 m^2)	Medic pods Weight (g/ m^2)	Others (No./0.1 m^2)	Others Weight (g/m^2)	DM	CP	OM
Before grazing									
Poultry	585.0	461.4	123.9	92.2	130.8	31.4	539.9	47.4	493.5
Sheep	502.4	395.1	100.6	81.5	102.6	25.7	462.9	41.9	423.5
P value	-	0.162	0.493	0.674	0.406	0.483	0.190	0.514	0.185
SEM	-	29.36	23.14	17.04	22.31	5.35	36.83	5.60	33.09
After grazing									
Poultry	490.6	456.4	96.5	69.5	41.8	8.1	417.8	50.4	374.4
Sheep	132.4	118.1	3.02	2.2	6.2	1.5	109.2	6.3	90.6
P value	0.000	0.017	0.001	0.002	0.020	0.020	0.017	0.002	0.016
SEM	16.02	73.12	11.45	8.93	8.04	1.50	66.77	6.10	60.83

Table 3: Number of weeds (No./0.1 m^2) in the herbage after grazing by sheep and poultry in the medic pasture paddocks

Animal	Barley grass	Rye grass	Other grass	Wire weed	Caltrop	Mustard	Potato weed	Medic/ clover	Soursobs	Unidentified weeds
Poultry	2.2	7.2	0.2	2.2	0.04	0.1	0.02	16.5	0.4	0.5
Sheep	1.3	1.7	0.1	0	0.04	0.1	0	3.9	1.0	1.6
P value	0.214	0.308	0.580	0.010	1.000	0.414	0.356	0.000	0.227	0.017
SEM	0.46	3.50	0.07	0.43	0.02	0.05	0.01	0.82	0.28	0.24

Table 4: Soil nitrogen and pH in the medic pasture grazed by poultry and sheep

Animal	Nitrate-N (mg/l)	Ammonia-N (mg/l)	pH-water	pH_0.01M CaCl
Before grazing				
Poultry	13.9	4.2	7.4	6.5
Sheep	10.8	5.0	7.0	6.0
P value	0.431	0.393	0.405	0.352
SEM	2.95	0.60	0.30	0.35
After grazing				
Poultry	18.4	0	7.2	6.2
Sheep	24.2	0.1	6.8	5.8
P value	0.203	0.356	0.417	0.506
SEM	2.87	0.09	0.09	0.12

Agronomic aspects: The herbage and herbage nutrient availability was much lower for sheep paddocks than poultry paddocks. This was expected as ruminants ingest more herbage than monogastrics. Also the stocking rate of sheep in the paddock was almost twice of the stocking rate of poultry in the paddock when assessed on a kg/ha basis. Sheep grazed the medic pods heavily leaving fewer pods than poultry. As a result the paddocks foraged by the poultry did not need to be sown with medic seed for the next season given the high abundance of seeds left. The soil nitrate-N increased after grazing by poultry or sheep, but there was no significant difference in soil nitrate-N between the poultry and sheep paddocks.

Snails are a huge problem in Southern Australia and cause considerable damage to crops. The snail population at the time of sampling was low probably because of the dry weather conditions. Likewise very few insects were also observed at the time of sampling. Sheep, however, were very effective in grazing wire weed, which contaminated the paddocks whereas poultry avoided this weed. In contrast, the number of unidentified weeds in the sheep paddock was greater than the poultry paddock. This raises the possibility that sheep and poultry could be grazed together in some circumstances, to provide a method for reducing weeds, using sheep to graze weeds they prefer and poultry to consume weed seeds that sheep avoid. The biosecurity aspects of this strategy would need to be evaluated. Grain yields did not differ between the sheep and poultry paddocks although the sheep paddocks produced a higher crude protein in the weight presumably because of the higher levels of nitrogen in the soil. Our results suggested that free-range poultry can utilize the forage resources in a crop and pasture rotation and not result in a build up of nutrients in the soil if stocked at sustainable levels. The integration of birds into the pasture system assisted in weed control. There is potential for small holder free-range farmers to utilize this system to earn income, reduce chemical input into soil, improve soil fertility and crop yield and change consumer perceptions about poultry products.

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