CHAPTER 4

Results

The following results were obtained during the 5 month trial period.

4.1.1. Egg production

The effect of housing system and breed on total egg production over 5 the month trial period is presented in Table 4.1. Unfortunately, it was not possible to get all the hens from the different breeds at point of lay. Therefore, data were only collected from after peak starting at 48 weeks of age for a total period of five months. The following measurements: egg production, egg weight, feed intake, feed conversion ratio and hen day production % of hens from all the breeds were taken from 48 weeks of age for a of 5 month trial period.

Table 4.1 The effect of breed and housing system on total egg production (± standard deviation) over the 5 month trial period

Types	Breeds	Housing system		Mean egg production for breed
		Dam house	Control house	
Commercial breeds	HB	118.7^{a} (± 6.97)	109.7^{b} (± 9.76)	114.17^{b} (± 9.30)
	HS	125.1^{a} (± 8.94)	123.4^{a} (± 10.32)	124.25^{a} (± 9.14)
	LB	121.4^{a} (± 8.30)	120.0^{ab} (± 4.07)	120.71^{ab} (±6.42)
	LS	127.6^{a} (± 4.23)	126.2^{a} (± 5.52)	126.91^{a} (± 4.70)
Dual purpose breeds	BA	86.8^{c} (± 4.41)	88.3^{cd} (± 10.58)	87.56^{d} (±7.68)
	NH	93.7^{bc} (± 6.95)	93.8^{c} (± 3.79)	93.74^{cd} (±5.03)
Indigenous breeds	OV	88.3^{c} (± 10.04)	82.4^{d} (± 8.20)	85.38^{d} (±9.18)
	PK	102.4^{b} (± 7.41)	95.4^{c} (± 7.58)	98.90^{c} (±7.99)
	Mean	**108.0 (± 17.55)**	**104.99 (±17.74)**	

$^{1-2}$ Row means with the same superscript do not differ significantly (P>0.05)
$^{a-d}$ Column means with the same subscript do not differ significantly (P>0.05)
HS=Hyline Silver; HB= Hyline Brown; LS= Lohman Silver; LB= Lohman Brown;
PK= Potchefstroom Koekoek; NH= New Hampshire; BA= Black Australorp; OV= Ovambo.

As shown in Table 4.1, there was no significant (P>0.05) difference in the total egg production over the 5 month period between commercial breeds kept in the dam house system. Egg production of commercial breeds was significantly higher (P<0.05) than the dual purpose and indigenous breeds. The Potchefstroom Koekoek had a significantly (P<0.05) higher egg production than the Black Australorp and Ovambo. There was no significant difference (P>0.05) in egg production between Black Australorp and Ovambo hens.

In the control house, there was a significant difference (P<0.05) in total egg production over the 5 months period between the commercial breeds. The Hyline-Brown hens had a significantly (P<0.05) lower egg production than the Hyline-Silver and Lohman-Silver. Egg production of the Hyline-Brown hens did not differ significantly (P>0.05) from the Lohman-Brown hens. The commercial breeds produced significantly (P<0.05) more eggs than the dual purpose and indigenous breeds. The Ovambo and Black Australorp hens produced the least eggs from all the different breeds kept in the control house.

There was no effect of housing system on the total egg production of laying hens over the trial period.

4.1.2. Monthly egg production

The effect of breed and housing system on the monthly egg production of laying hens is depicted in Table 4.2.

Table 4.2 The effect of breed and housing systems on monthly egg production (± standard deviation)

Months	Types	Breeds	Housing system: Dam house	Housing system: Control house	Mean egg production for breed
1	Commercial breeds	HB	25.35^{a} (± 1.24)	23.15^{a} (± 1.65)	24.25^{a} (± 1.80)
		HS	26.50^{a} (± 1.29)	23.13^{a} (± 4.09)	24.82^{a} (± 3.63)
		LB	26.95^{a} (± 1.97)	23.69^{a} (± 2.97)	25.32^{a} (± 2.86)
		LS	25.90^{a} (± 2.69)	26.20^{a} (± 1.09)	26.05^{a} (± 1.94)
	Dual purpose breeds	BA	13.70^{c} (± 2.86)	10.88^{d} (± 2.12)	12.92^{d} (± 2.79)
		NH	17.31^{b} (± 4.15)	19.30^{c} (± 3.09)	18.31^{b} (± 3.74)
	Indigenous breeds	OV	18.00^{b1} (± 3.01)	12.90^{d2} (± 3.29)	15.45^{c} (± 4.01)
		PK	19.30^{b} (± 2.61)	17.05^{c} (± 2.45)	18.18^{b} (± 2.66)
		Mean	**21.63 (± 5.49)**	**19.54 (± 5.80)**	
2	Commercial breeds	HB	24.65^{a} (± 1.10)	23.35^{a} (± 2.05)	24.00^{a} (± 1.69)
		HS	25.20^{a} (± 2.35)	23.15^{a} (± 4.06)	24.18^{a} (± 3.31)
		LB	24.70^{a} (± 0.96)	24.25^{a} (± 2.07)	24.48^{a} (±1.46)
		LS	24.90^{a} (± 1.88)	25.35 ^{a} (± 1.62)	25.13^{a} (± 1.68)
	Dual purpose breeds	BA	16.30^{c} (± 4.41)	13.53^{c} (± 5.25)	14.92^{c} (± 4.79)
		NH	18.31^{bc} (± 4.07)	17.70^{b} (± 2.56)	18.01^{bc} (± 3.21)
	Indigenous breeds	OV	19.15^{bc1} (± 2.62)	14.02^{bc2} (± 2.52)	16.58^{c} (± 3.63)
		PK	21.6^{ab1} (± 2.53)	17.70^{b2} (± 3.89)	19.65^{b} (± 3.72)
		Mean	**21.85 (± 4.28)**	**19.88 (± 5.35)**	
3	Commercial breeds	HB	24.20^{ab} (± 1.89)	20.60^{abc}(± 3.79)	22.40^{ab} (± 3.41)
		HS	26.05^{a} (± 2.56)	24.15^{a} (± 4.65)	25.10^{a} (± 3.68)
		LB	23.40^{abc} (± 3.14)	23.25^{ab} (± 3.42)	23.33^{ab} (± 3.06)
		LS	25.05^{ab} (± 2.76)	24.15^{a} (± 2.88)	24.60^{a} (± 2.70)
	Dual purpose breeds	BA	20.05^{cd} (± 1.35)	18.55^{c} (± 4.91)	19.30 ^{b} (± 3.49)
		NH	19.12^{d} (± 2.76)	19.05^{bc} (± 2.74)	19.09^{b} (± 2.57)
	Indigenous breeds	OV	19.75^{cd} (± 2.52)	19.55^{bc} (± 2.86)	19.65^{b} (± 2.55)
		PK	21.60^{bcd} (± 2.52)	21.10^{abc} (± 2.75)	21.35^{b} (± 2.50)
		Mean	**22.40 (± 3.34)**	**21.30 (± 3.91)**	

4	Commercial breeds	HB	23.00^{a} (±1.41)	19.80^{bc} (± 4.17)	21.40^{b} (± 3.38)
		HS	24.35^{a} (±2.40)	23.55^{a} (± 4.04)	23.95^{a} (± 3.16)
		LB	22.10^{ab} (± 2.93)	21.25^{ab} (± 3.09)	21.68^{ab} (± 3.84)
		LS	23.95^{a} (± 2.93)	23.65^{a} (± 2.98)	23.80^{ab} (± 2.79)
	Dual purpose breeds	BA	18.45^{c} (± 1.96)	17.35^{c} (± 3.66)	17.90^{c} (± 2.83)
		NH	16.50^{c} (± 1.90)	18.00^{bc} (± 2.82)	17.25^{c} (± 2.45)
	Indigenous breeds	OV	18.03^{c} (± 1.47)	18.94^{bc} (± 1.62)	18.51^{c} (± 1.54)
		PK	18.85^{bc} (± 3.26)	19.65^{bc} (± 2.39)	19.25^{bc} (± 2.73)
		Mean	**20.65 (± 3.56)**	**20.28 (± 3.67)**	
5	Commercial breeds	HB	21.45^{abc} (± 2.29)	17.80^{bc} (± 3.89)	19.62^{b} (± 3.57)
		HS	22.95^{ab} (± 1.87)	21.55^{ab} (± 4.14)	22.25^{ab} (± 3.12)
		LB	21.05^{abc} (± 3.23)	21.19^{ab} (± 2.99)	21.12^{ab} (± 2.98)
		LS	24.00^{a} (± 3.64)	21.90^{a} (± 4.22)	22.95^{a} (±3.87)
	Dual purpose breeds	BA	18.90^{c} (± 1.05)	17.55^{c} (± 3.52)	18.25^{bc} (± 2.55)
		NH	16.25^{d} (± 1.76)	17.30^{c} (± 2.62)	16.78^{bc} (± 2.21)
	Indigenous breeds	OV	16.25^{d} (± 2.76)	16.95^{c} (± 2.66)	16.60^{c} (± 2.58)
		PK	20.10^{bc} (± 1.65)	20.00^{ab} (± 2.77)	20.05^{b} (± 2.15)
		Mean	**20.12 (± 3.47)**	**19.28 (± 3.67)**	

[1-2] Row means with the same superscript do not differ significantly (P>0.05)
[a-d] Column means with the same subscript do not differ significantly (P >0.05)
HS=Hyline Silver; HB= Hyline Brown; LS= Lohman Silver; LB= Lohman Brown; PK= Potchefstroom Koekoek; NH= New Hampshire; BA= Black Australorp; OV= Ovambo.

During the 1st month of the trial, there was no significant difference (P>0.05) in egg production between the commercial breeds kept in both houses but commercial breeds produced significantly (P<0.05) more eggs than other breeds. In the dam house, Black Australorp hens produced significantly (P<0.05) less eggs than New Hampshire, Ovambo and Potchefstroom Koekoek hens. However, in the control house, both Black Australorp and Ovambo produced significantly (P<0.05) less eggs than New Hampshire and Potchefstroom Koekoek breeds. The housing system only affected egg production for the Ovambo breed where hens in the dam house produced significantly (P<0.05) more eggs than those in the control house.

During the second month of the trial period, commercial breeds produced significantly more (P<0.05) eggs than all the other breeds except Potchefstroom Koekoek (P>0.05) kept in the dam house. Egg production for Potchefstroom Koekoek did not differ significantly from that of New Hampshire and Ovambo breeds (P>0.05). However, in the control house, commercial breeds produced significantly higher eggs (<P0.05) than all the other breeds. Although no significant difference was noticed between New Hampshire, Ovambo and Potchefstroom Koekoek (P>0.05), both New Hampshire and Potchefstroom Koekoek produced significantly (P<0.05) more eggs than Black Australorp, in the control house. However, the housing system only affected the indigenous breeds (Ovambo and Potchefstroom Koekoek) where egg production was significantly lower (P<0.05) in the control house.

Although there was no significant (P>0.05) difference in egg production within the commercial breeds in the dam house during the third month, it was only the Hyline-Silver which produced significantly (P<0.05) more eggs than the other breeds. No significant (P>0.05) difference was noticed between Potchefstroom Koekoek and commercial hens, in the control house. With the exception of Hyline-Silver, in the dam house, egg production for Potchefstroom Koekoek did not differ significantly from other commercial breeds as well as the dual and indigenous breeds (P>0.05), in both houses. However, no significant effects (P≥0.05) of the housing systems were noticed.

In the dam house, no significant (P>0.05) differences in egg production occurred during the fourth month between commercial breeds. Although egg production for the Potchefstroom Koekoek did not differ significantly with the dual and indigenous breeds in the dam house, it also did not differ (P>0.05) with that of Lohman-Brown hens, a commercial breed. In the control house, only Hyline-Silver and Lohman-Silver produced significantly (P<0.05) more eggs than other breeds. Lohman-Brown hens only produced significantly (P<0.05) more eggs than Black Australorp whose production was the same (P>0.05) as that of Hyline-Brown. Again, no significant effects of the housing systems were observed in egg production of laying hens during the fourth month.

During the fifth month of the trial period, there was no significant difference (P>0.05) in egg production between the commercial breeds kept in the dam house but only Lohman-Silver produced significantly (P<0.05) more eggs than all other breeds. Egg production for Hyline-Silver was significantly (P<0.05) higher than for the other breeds except for the Potchefstroom Koekoek. Both Hyline Brown and Lohman-Brown had the same (P>0.05) egg production than the Potchefstroom Koekoek and Black Australorp while Ovambo and New Hampshire produced less (P<0.05) eggs than all other breeds. In the control house, Lohman-Silver produced significantly (P<0.05) more eggs than Hyline-Brown although its production did not differ (P>0.05) from the rest of the commercial breeds. Potchefstroom Koekoek hens had the same (P>0.05) egg production than the commercial breeds but its production was significantly (P<0.05) higher than other dual and indigenous breeds, whose production was the same (P>0.05) as that of Hyline-Brown. No significant effect of housing systems was noticed for egg production of laying hens during the fifth month.

4.1.3. Egg weight

The mean egg weight produced by laying hens of different breeds in two different housing systems within a five month trial period is shown in Table 4.3.

Table 4.3 The effect of breed and housing system on mean egg weight (g) (± standard deviation) over the 5 month trial period

Types	Breeds	Housing system		Mean egg weight for breed
		Dam house	Control house	
Commercial breeds	HB	48.43[ab] (± 6.11)	44.74[ab] (± 15.80)	46.59[a] (± 11.46)
	HS	50.47[a] (± 2.88)	48.72[a] (± 6.63)	49.60[a] (± 4.91)
	LB	53.32[a] (± 2.96)	47.63[ab] (± 3.48)	50.47[a] (± 4.22)
	LS	46.28[ab] (± 8.59)	43.78[ab] (± 12.92)	45.03[ab] (± 10.43)
Dual purpose breeds	BA	30.85[c] (± 4.58)	35.93[bc] (± 10.62)	33.39[bc] (± 8.16)
	NH	29.52[c] (± 13.12)	38.38[abc] (± 5.55)	33.95[bc] (± 10.08)
Indigenous breeds	OV	28.29[c] (± 10.74)	28.27[c] (±15.40)	28.28[c] (± 12.52)
	PK	38.11[bc] (± 5.70)	37.30[abc] (±3.51)	37.70[b] (± 4.48)
	Mean	**40.94 (± 11.71)**	**40.59 (± 11.54)**	

[1-2] Row means with the same superscript do not differ significantly (P >0.05)
[a-c] Column means with the same subscript do not differ significantly (P >0.05)
HS=Hyline Silver; HB= Hyline Brown; LS= Lohman Silver; LB= Lohman Brown;
PK= Potchefstroom Koekoek; NH= New Hampshire; BA= Black Australorp; OV= Ovambo.

In the dam house, the mean egg weight of the commercial breeds during the trial period did not differ significantly (P>0.05) from each other, but only Hyline-Silver and Lohman-Brown produced significantly (P<0.05) heavier eggs than all the other breeds. No significant (P>0.05) differences were detected between egg weights of both dual and indigenous breeds. With the exception of Potchefstroom Koekoek, the dual purpose and indigenous breeds produced significantly lighter (P<0.05) eggs than the commercial breeds.

There was no significant difference (P>0.05) in egg weight between dual and indigenous breeds, and within commercial breeds in the control house. However, egg weight for both New Hampshire and Potchefstroom Koekoek did not differ significantly (P>0.05) from that of the commercial breeds. On the other hand, eggs of the Ovambo was significantly (P<0.05) lighter than that of all commercial breeds, while the Black Australorp hens produced significantly lighter eggs than the commercial breeds. The housing systems had no significant (P>0.05) effect on egg weight of laying hens over the trial period.

4.1.4. Monthly egg weight

The effect of breed and housing system on the monthly egg weight of laying hens is shown in Table 4.4.

Table 4.4 The effect of breed and housing system on monthly mean egg weight (g) (± standard deviation) of laying hens

Months	Types	Breeds	Housing system		Mean egg weight for breed
			Dam house	Control house	
1	Commercial breeds	HB	63.12^{a} (± 1.22)	63.28^{a} (± 0.73)	63.20^{a} (± 0.95)
		HS	58.72^{b1} (± 1.76)	60.97^{b2} (± 0.85)	59.84^{c} (± 1.76)
		LB	62.77^{a1} (± 2.17)	60.77^{b2} (± 1.39)	61.78^{b} (± 2.05)
		LS	58.75^{b} (± 3.04)	57.77^{c} (± 0.81)	58.26^{d} (± 2.16)
	Dual purpose breeds	BA	55.80^{c} (± 1.06)	57.30^{c} (± 0.55)	56.55^{e} (± 1.12)
		NH	55.34^{c} (± 0.97)	57.08^{c} (± 0.98)	56.21^{e} (± 1.26)
	Indigenous breeds	OV	56.95^{bc} (± 1.69)	54.67^{d} (± 0.67)	55.81^{ef} (± 1.71)
		PK	54.68^{c} (± 1.10)	55.05^{d} (± 1.32)	54.87^{f} (± 1.16)
		Mean	**58.27 (± 3.44)**	**58.36 (± 3.00)**	
2	Commercial breeds	HB	63.24^{a} (± 1.24)	63.04^{a} (± 1.24)	63.14^{a} (± 1.17)
		HS	58.47^{bc} (± 0.52)	53.04^{d} (± 1.09)	58.39^{b} (± 0.81)
		LB	63.93^{a} (± 3.02)	61.29^{a} (± 1.35)	62.61^{a} (± 2.68)
		LS	60.05^{b1} (± 1.01)	58.25^{b2} (± 1.11)	59.15^{b} (± 1.37)
	Dual purpose breeds	BA	55.62^{c1} (± 1.14)	57.53^{b2} (± 1.46)	56.57^{c} (± 1.59)
		NH	56.91^{c} (± 1.29)	55.68^{c} (± 1.20)	56.30^{c} (± 1.29)
	Indigenous breeds	OV	55.83^{c} (± 1.41)	54.16^{c} (± 1.48)	54.99^{d} (± 1.62)
		PK	55.24^{c} (± 0.75)	54.64^{c} (± 0.61)	54.94 ^{d} (± 0.72)
		Mean	**58.66 (± 3.53)**	**57.86 (± 3.13)**	
3	Commercial breeds	HB	65.10^{a} (± 3.92)	66.88^{a} (± 2.16)	65.99^{a} (± 3.12)
		HS	58.99^{b} (± 1.07)	58.19^{c} (± 0.84)	58.59^{cd} (± 1.00)
		LB	64.17^{a1} (± 2.01)	61.24^{b2} (± 2.77)	62.71^{b} (± 2.69)
		LS	60.89^{b1} (± 0.79)	58.08^{c2} (± 1.09)	59.48^{c} (± 1.74)
	Dual purpose breeds	BA	56.86^{c} (± 0.91)	57.28^{c} (± 0.77)	57.07^{d} (± 0.83)
		NH	55.82^{cd} (± 1.49)	57. 39^{c} (± 0.75)	56.61^{de} (± 1.34)
	Indigenous breeds	OV	56.60^{cd} (± 1.38)	54.64^{d} (± 0.36)	55.62^{e} (± 1.41)
		PK	54.59^{d} (± 0.91)	55.12^{d} (± 0.64)	54.85^{e} (± 0.79)
		Mean	**59.13 (± 4.07)**	**58.60 (± 3.91)**	
4	Commercial breeds	HB	62.88^{ab} (± 1.55)	64.49^{a} (± 1.26)	63.68^{a} (± 1.58)
		HS	59.17^{c} (± 1.33)	59.63^{c} (± 1.94)	59.04^{b} (± 1.58)
		LB	63.95^{a} (± 3.05)	62.26^{b} (± 2.18)	63.11^{a} (± 2.69)
		LS	61.19^{b1} (± 0.61)	58.25^{cd2} (± 1.46)	59.72^{b} (± 1.87)
	Dual purpose breeds	BA	55.83^{d} (± 1.27)	57.59^{d} (± 1.41)	56.71^{c} (± 1.57)
		NH	55.76^{d} (± 0.62	56.29^{d} (± 0.72)	56.02^{c} (± 0.69)
	Indigenous breeds	OV	55.27^{d} (± 1.44)	55.68^{d} (± 0.96)	55.48^{c} (± 1.17)
		PK	56.72^{d} (± 1.81)	55.96^{d} (± 0.64)	56.34^{c} (± 1.35)
		Mean	**58.84 (± 3.61)**	**58.77 (± 3.25)**	

5	Commercial breeds	HB	63.16^{ab1} (± 1.22)	65.82^{a2} (± 1.69)	64.49a (± 1.98)
		HS	59.26^{c} (± 1.27)	60.70^{c} (± 0.54)	59.98c (± 1.19)
		LB	64.13^{a} (± 1.07)	62.52^{b} (± 1.88)	63.32b (± 1.62)
		LS	61.78^{b1} (± 0.94)	58.82^{de2} (± 0.83)	60.30c (± 1.77)
	Dual purpose breeds	BA	55.60^{d1} (± 1.33)	59.03^{d2} (± 1.01	57.30d (± 2.14)
		NH	57.93^{c} (± 0.57)	57.28^{e} (± 1.19	57.61d (± 0.98)
	Indigenous breeds	OV	55.81^{d1} (± 2.24)	54.01^{f2} (± 0.93)	54.91e (± 1.87)
		PK	55.96^{d} (± 1.22)	55.78^{f} (± 1.09)	55.77e (± 1.11)
		Mean	**59.20 (± 3.52)**	**59.22 (± 3.76)**	

^{12} Row means with the same superscript do not differ significantly (P >0.05)
$^{a\text{-}f}$ Column means with the same subscript do not differ significantly (P >0.05)
HS=Hyline Silver; HB= Hyline Brown; LS= Lohman Silver; LB= Lohman Brown;
PK= Potchefstroom Koekoek; NH= New Hampshire; BA= Black Australorp; OV= Ovambo

During the first month, Hyline-Brown and Lohman-Brown produced significantly heavier eggs (P<0.05) than all the other breeds in the dam house. Hyline-Silver and Lohman-Silver also produced significantly (P<0.05) heavier eggs than the dual purpose and indigenous breeds except Ovambo. In the control house, Hyline-Brown produced significantly (P<0.05) heavier eggs than all the other breeds. Lohman-Silver produced the same egg weights as the dual purpose whilst the indigenous breeds produced significantly (P<0.05) lighter eggs than all the other breeds. A house effect was only observed for Hyline-Silver, producing lighter eggs in the dam house than the control house while the inverse occurred with Lohman-Brown (P<0.05).

In both housing systems, Hyline-Brown and Lohman-Brown produced significantly (P<0.05) heavier eggs than the other breeds during the second month. In the control house, Hyline-Silver produced lighter eggs than all the other breeds (P<0.05) while Black Australorp and Lohman-Silver produced heavier (P<0.05) eggs than the rest of dual and indigenous breeds. Egg weight for Hyline-Silver declined while that of Black Australorp increased in the control house (P<0.05).

During the third month, all commercial breeds produced significantly (P<0.05) heavier eggs than other breeds in the dam house. Hyline-Brown and Lohman-Brown hens produced significantly heavier eggs than Hyline-Silver and Lohman-Silver hens. Black Australorps produced significantly (P<0.05) heavier eggs than Potchefstroom Koekoeks. No significant (P>0.05) differences were detected between egg weight for Potchefstroom Koekoek and that of New Hampshire and Ovambo. Although Hyline-Brown produced significantly (P<0.05) heavier eggs than Lohman-Brown, both breeds produced heavier (P<0.05) eggs than the rest of the breeds in the control house. Indigenous breeds produced significantly (P<0.05) lighter eggs than the dual breeds as well as Hyline-Silver and Lohman-Silver breeds. Hyline-Brown and Lohman-Brown hens produced significantly (P<0.05) heavier eggs in the dam house than the control house.

Hyline-Silver produced the lightest eggs and Hyline-Brown the heaviest of all commercial breeds in the dam house and control house, respectively (P<0.05), during the 4th month. In the dam house, Lohman-Brown had significantly (P<0.05) heavier eggs than Lohman-Silver but not Hyline-Brown. All commercial breeds produced significantly heavier eggs than the dual purpose and indigenous breeds in the dam house. In the control house, both Hyline-Silver and Lohman-Silver produced significantly (P<0.05) lighter eggs than the other commercial breeds. Egg weights for Lohman-Silver did not differ significantly with that of dual purpose and indigenous breeds. Breed and house interaction were only detected for Lohman-Silver where eggs significantly lighter (P<0.05) in the control house than in the dam house.

During the fifth month, Hyline-Silver produced significantly (P<0.05) lighter eggs than other commercial breeds in the dam house. Within the commercial breeds significant (P<0.05) differences were only noticed between egg weights of Lohman-Brown and Lohman-Silver. With the exception of Hyline-Silver, which had the same egg weight with New Hampshire, all commercial breeds produced significantly (P<0.05) heavier eggs than dual and indigenous breeds. New Hampshire hens also produced heavier (P<0.05) eggs than the rest of the dual and also the indigenous breeds. In the control house, Lohman-Silver produced significantly (P<0.05) lighter eggs than other commercial breeds. Egg weight differed significantly (P<0.05) within commercial breeds with the heaviest eggs produced by Hyline-Brown followed by Hyline-Silver and Lohman-Brown. Black Australorp produced heavier (P<0.05) eggs than New Hampshire but the eggs of both breeds were significantly heavier than indigenous breeds. Eggs of the Ovambo and Lohman-Silver hens were significantly heavier, in the dam house while the inverse occurred for Black Australorp and Hyline-Brown.

4.1.5. Feed intake

The effect of breed and housing system on average daily feed intake of laying hens is outlined in Table 4.5.

Table 4.5 The effect of breed and housing system on average daily feed intake (g) (± standard deviation) over the 5 month trial period

Types	Breeds	Housing system		Mean feed intake for breed
		Dam house	Control house	
Commercial breeds	HB	149.96^{a} (± 0.011)	149.87^{ab} (± 0.113)	149.91 (± 0.089)
	HS	149.97^{a} (± 0.005)	149.95^{a} (± 0.025)	149.96 (± 0.019)
	LB	149.96^{a} (± 0.008)	149.94^{ab} (± 0.029)	149.95 (± 0.021)
	LS	149.96^{a1} (± 0.011)	149.85^{b2} (± 0.104)	149.90 (± 0.090)
Dual purpose breeds	BA	149.92^{a} (± 0.082)	149.90^{ab} (± 0.116)	149.91 (± 0.095)
	NH	149.96^{a} (± 0.008)	149.88^{ab} (± 0.095)	149.92 (± 0.079)
Indigenous breeds	OV	149.95^{a1} (± 0.009)	149.86^{b2} (± 0.137)	149.91 (± 0.105)
	PK	149.95^{a} (± 0.005)	149.89^{ab} (± 0.084)	149.92 (± 0.065)
	Mean	**149.95 (± 0.032)**	**149.89 (± 0.094)**	

^{12} Row means with the same superscript do not differ significantly (P>0.05)
^{ab} Column means with the same subscript do not differ significantly (P>0.05)
HS=Hyline Silver; HB= Hyline Brown; LS= Lohman Silver; LB= Lohman Brown; PK= Potchefstroom Koekoek; NH= New Hampshire; BA= Black Australorp; OV= Ovambo.

No significant differences (P>0.05) were noticed for feed intake between breeds and housing system over the total five month trial period and within months. All the hens finished the daily feed ration of 150g/hen/day allocated to them. Differences were too small to even worth mentioning.

4.1.6. Feed conversion ratio (FCR)

The effect of breed and housing systems on the feed conversion ratio over the 5 month trial period is shown in Table 4.6.

Table 4.6 The effect of breed and housing system on the feed conversion ratio (total feed intake/eggs weight) (± standard deviation) over the 5 month trial period

Types	Breeds	Housing system		Mean FCR for breed
		Dam house	Control house	
Commercial breeds	HB	3.04^{d} (± 0.146)	2.83^{c} (± 0.145)	2.94^{c} (± 0.177)
	HS	3.07^{d} (± 0.249)	3.10^{c} (± 0.189)	3.09^{c} (± 0.209)
	LB	2.83^{d} (± 0.133)	3.08^{c} (± 0.080)	2.96^{c} (± 0.167)
	LS	2.88^{d} (± 0.106)	3.08^{c} (± 0.132)	2.98^{c} (± 0.152)
Dual purpose breeds	BA	4.72^{a1} (± 0.182)	3.93^{b2} (± 0.384)	4.33^{a} (± 0.503)
	NH	4.27^{bc} (± 0.210)	4.27^{a} (± 0.306)	4.27^{ab} (± 0.252)
Indigenous breeds	OV	4.06^{c1} (± 0.237)	4.48^{a2} (± 0.201)	4.27^{ab} (± 0.304)
	PK	3.88^{c} (± 0.318)	4.24^{a} (± 0.392)	4.07^{b} (± 0.385)
	Mean	**3.58 (± 0.71)**	**3.64 (± 0.68)**	

[12] Row means with the same superscript do not differ significantly (P >0.05)
[a-d] Column means with the same subscript do not differ significantly (P>0.05)
HS=Hyline Silver; HB= Hyline Brown; LS= Lohman Silver; LB= Lohman Brown;
PK= Potchefstroom Koekoek; NH= New Hampshire; BA= Black Australorp; OV= Ovambo.

As expected, commercial breeds had a significantly (P<0.05) better feed conversion ratio than dual purpose and indigenous breeds, in both housing systems. Feed conversion ratio varied significantly among dual and indigenous breeds. Among these breeds, Potchefstroom Koekoeks had the best (P<0.05) FCR in the dam house but not in the control house. The inverse was true for Black Australorp, which had the poorest FCR in the dam house but a significantly (P<0.05) better FCR in the control house. The FCR for Ovambo also improved significantly (P<0.05) in the dam house, as compared to its FCR in the control house.

4.1.7. The monthly feed conversion ratio

The effect of breed and housing system on feed conversion ratios of laying hens during different monthly periods is outlined in Table 4.7.

Table 4.7 The effect of breed and housing systems on feed conversion ratio (total feed intake/eggs weight) (± standard deviation) of laying hens during different monthly periods

Months	Types	Breeds	Housing system: Dam house	Housing system: Control house	Mean monthly FCR for breed
1	Commercial breeds	HB	2.86^{d} (± 0.101)	2.81^{c} (± 0.175)	2.86^{c} (± 0.137)
		HS	2.89^{d} (± 0.094)	2.96^{c} (± 0.186)	2.89^{c} (± 0.144)
		LB	2.69^{d} (± 0.209)	2.96^{c} (± 0.126)	2.69^{c} (± 0.219)
		LS	2.82^{d} (± 0.142)	2.93^{c} (± 0.065)	2.81^{c} (± 0.120)
	Dual purpose breeds	BA	4.03^{b1} (± 0.448)	3.33^{b2} (± 0.346)	4.03^{b} (± 0.502)
		NH	4.26^{ab1} (± 0.083)	3.85^{a2} (± 0.222)	4.26^{a} (± 0.268)
	Indigenous breeds	OV	4.44^{a1} (± 0.591)	3.77^{a2} (± 0.144)	4.44^{a} (± 0.537)
		PK	3.67^{c} (± 0.257)	3.88^{a} (± 0.050)	3.67^{b} (±0.208)
		Mean	**3.46 (± 0.74)**	**3.31 (± 0.47)**	
2	Commercial breeds	HB	2.88^{c} (± 0.111)	2.81^{c} (± 0.159)	2.88^{c} (± 0.134)
		HS	2.91^{c} (± 0.075)	3.00^{c} (± 0.261)	2.91^{c} (± 0.187)
		LB	2.93^{c} (± 0.035	2.88^{c} (± 0.062	2.93^{c} (± 0.051)
		LS	2.92^{c} (± 0.051)	3.02^{c} (± 0.128)	2.92^{c} (±0.106)
	Dual purpose breeds	BA	5.22^{a1} (± 1.121)	3.78^{b2} (± 0.474)	5.22^{a} (± 1.132)
		NH	3.92^{b} (± 0.381)	3.78^{b} (± 0.135)	4.01^{b} (± 0.297)
	Indigenous breeds	OV	3.70^{b} (± 0.235)	4.12^{ab} (± 0.170)	3.07^{b} (± 0.296)
		PK	3.65^{b1} (± 0.266)	4.30^{a2} (± 0.605)	3.65^{b} (± 0.558)
		Mean	**3.52 (± 0.87)**	**3.46 (± 0.63)**	
3	Commercial breeds	HB	2.74^{cd}(± 0.137)	2.74^{c}(± 0.229)	2.74^{e} (± 0.178)
		HS	2.85^{c}(± 0.172)	2.80^{c} (± 0.088)	2.85^{de}(± 0.131)
		LB	2.62^{d1}(± 0.201)	2.93^{c2} (± 0.040)	2.62^{de}(± 0.222)
		LS	2.86^{c}(± 0.071)	2.94^{c} (± 0.045)	2.86^{de}(± 0.071)
	Dual purpose breeds	BA	3.63^{b1} (± 0.162)	3.40^{b2} (± 0.093)	3.63^{c} (± 0.251)
		NH	3.92^{a} (± 0.060)	3.79^{a} (± 0.232)	3.92^{a} (± 0.182)
	Indigenous breeds	OV	3.61^{b} (± 0.246)	3.81^{a} (± 0.143)	3.61^{ab}(± 0.216)
		PK	3.63^{b}(± 0.274)	3.72^{a} (± 0.202)	3.63^{b} (± 0.232)
		Mean	**3.23 (± 0.51)**	**3.27 (± 0.46)**	
4	Commercial breeds	HB	3.01^{b}(± 0.109)	2.71^{c} (± 0.141)	3.01^{c}(± 0.198)
		HS	3.07^{b} (± 0.226)	2.91^{c} (± 0.060)	3.07^{bc}(± 0.177)
		LB	2.94^{b}(± 0.163)	3.27^{b} (± 0.108)	2.94^{b}(± 0.218)
		LS	2.93^{b}(± 0.131)	2.94^{bc} (± 0.042)	2.93^{bc}(± 0.092)
	Dual purpose breeds	BA	3.97^{a} (± 0.099)	3.70^{a} (± 0.125)	3.97^{a} (±0.203)
		NH	4.18^{a}(± 0.478)	3.96^{a} (± 0.086)	4. 17^{a}(± 0.320)
	Indigenous breeds	OV	3.87^{a} (±0.479)	3.89^{a} (± 0.129)	3.87^{a}(± 0.342)
		PK	4.13^{a}(± 0.626)	3.86^{a} (± 0.151)	4.13^{a}(± 0.452)
		Mean	**3.51 (± 0.62)**	**3.40 (± 0.50)**	

5	Commercial breeds	HB	2.83^{cd} (± 0.076)	2.77^{d}(± 0.132)	2.83^{d}(± 0.107)
		HS	2.97^{c} (± 0.111)	2.83^{d}(± 0.111)	2.97^{d}(± 0.126)
		LB	2.70^{d} (± 0.132)	2.87^{d}(± 0.110)	2.70^{d}(± 0.145)
		LS	2.81^{cd} (± 0.116)	2.78^{d} (± 0.113)	2.81^{d}(± 0.109)
	Dual purpose breeds	BA	3.42^{b} (± 0.232)	3.34^{b} (± 0.190)	3.42^{c}(± 0.199)
		NH	4.05^{a1} (± 0.373)	3.71^{a2} (± 0.229)	4.05^{a}(± 0.332)
	Indigenous breeds	OV	3.87^{a} (± 0.078)	3.81^{a} (± 0.300)	3.87^{a}(± 0.205)
		PK	3.59^{b} (± 0.225)	3.60^{ab} (± 0.322)	3.59^{b}(± 0.261)
		Mean	**3.28 (± 0.51)**	**3.21 (± 0.46)**	

^{12} Row means with the same superscript do not differ significantly (P >0.05)
$^{a\text{-}d}$ Column means with the same subscript do not differ significantly (P >0.05)
HS=Hyline Silver; HB= Hyline Brown; LS= Lohman Silver; LB= Lohman Brown;
PK= Potchefstroom Koekoek; NH= New Hampshire; BA= Black Australorp; OV= Ovambo

Commercial breeds in both housing systems showed less variation in FCR during the first two months of the trial, in both housing systems, and had better (P<0.05) FCR throughout the trial. During the first month, Potchefstroom Koekoek in the dam house had significantly (P<0.05) better FCR than other dual purpose and indigenous breeds in the dam house. In the control house, Black Australorp hens had significantly (P<0.05) better FCR than other breeds in these categories. With the exception of Potchefstroom Koekoek, all other dual and indigenous breeds had significantly (P<0.05) better FCR in the control house than in the dam house.

During the second month, Black Australorp hens had significantly (P<0.05) worse FCR than other dual and indigenous breeds in the dam house, while Potchefstroom Koekoek had significantly better FCR than dual breeds only. The FCR for Black Australorp hens in the control house was significantly (P<0.05) better the FCR of the breeds in the dam house. The Potchefstroom Koekoek hens kept in the dam house had a better FCR than the Potchefstroom Koekoek hens in the control house.

During the third month of the trial, there were no significant (P>0.05) differences in FCR between the commercial breeds in the control house. In the dam house, Lohman-Brown and the Hyline-Brown had significantly (P<0.05) lower FCRs than the other two commercial breeds. New Hampshire hens had significantly (P<0.05) a higher FCR than other dual and indigenous breeds in the dam house. The FCR for Lohman-Brown was significantly (P<0.05) higher in the control house than in the dam house, while that of Black Australorp hens was lower in the control house than in the dam house. Compared to all the breeds in the control house, the Black Australorp performed best in terms of its FCR.

During the fourth month, there were no significant (P>0.05) differences in FCR between commercial breeds in the dam house as well as that of dual and indigenous breeds in both the housing systems. However, in the control house Lohman Brown had a significantly lower FCR than Hyline-Brown and Hyline-Silver. There was no breed and house interaction during this month in the trial period.

During the fifth month, no significant (P>0.05) differences in FCR occurred within commercial breeds in the control house, but Hyline-Silver had a significantly (P<0.05) lower FCR than

Lohman-Brown, in the dam house. Black Australorp and Potchefstroom Koekoek had significantly (P<0.05 lower FCR than New Hampshire and Ovambo breeds in the dam house. In the control house, while only Black Australorp hens had a significantly (P<0.05) lower FCR than the rest of the dual and indigenous breeds. New Hampshire hens had significantly (P<0.05) higher FCR, in the control than dam house. The FCR of the New Hampshire hens that were kept in the control house was significantly lower (P<0.05) compared to the FCR of the New Hampshire hens in the dam house.

4.1.8 Hen day production percentage

The effect of breed and housing system on hen day production percentage of laying hens over 5 months period is outlined in Table 4.8.

Table 4.8 The effect of breed and housing system on the hen day production % (± standard deviation) over the 5 month trial period

Types	Breeds	Housing system		Mean hen-day production %
		Dam house	Control house	
Commercial Breeds	HB	80.75^{b} (± 4.147)	80.35^{a} (± 2.416)	80.55^{b} (± 3.21)
	HS	85.29^{ab} (± 2.384)	82.81^{a} (± 5.349)	84.05^{ab} (± 4.12)
	LB	84.30^{ab} (± 4.239)	79.67^{a} (± 1.326)	81.98^{ab} (± 3.95)
	LS	87.03^{a} (± 2.560)	84.11^{a} (± 3.679)	85.57^{a} (± 3.36)
Dual purpose Breeds	BA	59.57^{cd1} (± 1.177)	64.93^{b2} (± 3.008)	62.25^{d} (± 3.55)
	NH	64.15^{cd} (± 3.461)	63.45^{b} (± 2.206)	63.81^{cd} (± 2.66)
Indigenous Breeds	OV	59.43^{d} (± 6.117)	54.94^{c} (± 5.470)	57.18^{e} (± 5.96)
	PK	68.27^{c} (± 5.572)	63.59^{b} (± 5.074)	65.93^{c} (± 5.59)
	Mean	**73.84 (± 11.92)**	**71.53 (± 11.23)**	

^{12} Row means with the same superscript do not differ significantly (P>0.05)
$^{a-e}$ Column means with the same subscript do not differ significantly (P >0.05)
HS=Hyline Silver; HB= Hyline Brown; LS= Lohman Silver; LB= Lohman Brown;
PK= Potchefstroom Koekoek; NH= New Hampshire; BA= Black Australorp; OV= Ovambo.

There were no significant differences in hen day production percentage (HDP %) between commercial breeds kept in the control house. For the birds in the control house, Lohman Silver had a significantly higher HDP % than Hyline-Brown. The HDP % for commercial breeds was significantly higher than that of dual and indigenous breeds in the two housing systems. In addition, the Ovambo breed had significantly lower HDP% than Potchefstroom Koekoek in both housing systems. The type of housing had an effect only on Black Australorp hens where HDP% was significantly higher in the control house.

4.1.9. Monthly hen-day production percentage

The results of the effect of breed and housing systems on monthly hen day production % of laying hens at different monthly periods are outlined in Table 4.9. Commercial breeds generally had significantly higher HDP % than dual and indigenous breeds for the first three months of the trial.

Table 4.9. The effect of breed and housing systems on monthly hen day production % (± standard deviation)

Month	Type	Breeds	Housing system: Dam house	Housing system: Control house	Mean monthly hen-day production %
1	Commercial Breeds	HB	84.51^{a} (± 4.15)	84.22^{ab} (± 3.06)	84.37^{a}(± 3.44)
		HS	88.33^{a1} (± 4.29)	81.45^{b2} (± 4.69)	84.89^{a}(± 5.58)
		LB	89.84^{a} (± 6.58)	85.07^{ab} (± 3.11)	87.45^{a} (± 5.62)
		LS	86.33^{a} (± 8.99)	89.05^{a} (± 2.71)	87.69^{a} (± 6.42)
	Dual purpose Breeds	BA	64.22^{b} (± 8.73)	63.33^{cd} (± 6.87)	63.78^{b}(± 7.42)
		NH	64.44^{b} (± 5.13)	69.33^{c} (± 3.46)	66.89^{b}(± 5.35)
	Indigenous Breeds	OV	65.00^{b} (± 3.17)	59.89^{d} (± 8.02)	62.44^{c} (± 6.35)
		PK	68.67^{b} (± 3.77)	67.00^{c} (± 2.21)	67.83^{b} (± 3.04)
		Mean	**76.42 (± 12.59)**	**74.92 (± 11.50)**	
2	Commercial Breeds	HB	82.67^{a} (± 2.97)	83.94^{a} (± 2.74)	83.30^{a} (±2.78)
		HS	86.95^{a} (± 2.83)	82.67^{a} (± 7.64)	84.81^{a} (± 5.88)
		LB	82.67^{a} (± 2.73)	83.12^{a} (± 2.75)	82.90^{a} (± 2.57)
		LS	84.50^{a} (± 3.37)	84.67^{a} (± 3.56)	84.58^{a}(± 3.27)
	Dual purpose Breeds	BA	51.72^{d} (± 9.27)	50.11^{c} (± 10.76)	50.92^{c} (± 9.51)
		NH	64.31^{c} (± 3.61)	61.22^{b} (± 4.49)	62.76^{b} (± 4.01)
	Indigenous Breeds	OV	62.00^{c1} (± 5.69)	48.50^{c2} (± 5.63)	55.25^{c} (± 8.89)
		PK	75.06^{b1} (± 3.93)	54.83^{bc2} (± 7.21)	64.95^{b} (±11.98)
		Mean	**73.73 (± 13.04)**	**68.63 (± 16.59)**	
3	Commercial Breeds	HB	82.33^{b} (± 6.87)	79.39^{b} (± 5.16)	80.86^{b} (± 5.93)
		HS	88.67^{a} (± 4.92)	88.05^{a} (± 5.24)	88.36^{a} (± 4.08)
		LB	84.22^{ab} (± 7.95)	83.20^{ab} (± 3.16)	83.71^{b} (± 5.97)
		LS	87.11^{ab} (± 2.29)	85.00^{ab} (± 3.12)	86.06^{ab} (±2.80)
	Dual purpose Breeds	BA	65.72^{d} (± 5.19)	68.72^{c} (± 7.29)	67.22^{c} (± 6.17)
		NH	71.46^{cd} (± 1.42)	68.72^{c} (± 3.61)	70.09^{c} (±3.06)
	Indigenous Breeds	OV	71.50^{cd} (± 2.07)	69.50^{c} (± 1.80)	70.50^{c} (± 2.11)
		PK	74.28^{c} (± 5.67)	70.67^{c} (± 3.29)	72.47^{c} (± 4.77)
		Mean	**78.16 (± 9.31)**	**76.66 (± 8.70)**	
4	Commercial Breeds	HB	78.45^{b} (± 3.28)	82.70^{b} (± 2.54)	80.57^{b} (± 3.56)
		HS	84.88^{a} (± 5.51)	89.94^{a} (± 4.19)	87.41^{a} (± 5.33)
		LB	81.49^{ab} (± 8.49)	77.16^{bc} (± 0.98)	79.32^{b} (± 6.54)
		LS	86.44^{a} (± 1.87)	86.15^{a} (± 4.11)	86.29^{a} (± 3.02)
	Dual purpose Breeds	BA	59.31^{cd} (± 2.62)	69.08^{c} (± 2.82)	64.19^{c} (± 5.75)
		NH	53.23^{d} (± 2.27)	68.10^{c} (± 0.61)	60.67^{d} (± 7.97)
	Indigenous Breeds	OV	62.36^{c} (± 4.06)	73.39^{c} (± 1.74)	67.87^{c} (± 6.52)
		PK	64.25^{c} (± 3.14)	68.56^{c} (± 2.50)	66.41^{c} (±8.67)
		Mean	**71.30 (± 13.27)**	**76.89 (± 8.56)**	

5	Commercial Breeds	HB	77.92^{c} (± 6.42)	77.80^{c} (± 4.90)	77.86^{c} (± 5.38)
		HS	83.93^{b} (± 2.82)	84.40^{b} (± 3.21)	84.17^{b} (± 2.86)
		LB	86.07^{ab} (± 2.57)	82.74^{b} (± 1.63)	84.40^{b} (± 2.72)
		LS	90.18^{a} (± 3.34)	90.00^{a} (± 2.78)	90.09^{a} (± 2.90)
	Dual purpose Breeds	BA	65.89^{e} (± 0.74)	74.58^{cd} (± 3.80)	70.24^{d} (± 5.26)
		NH	64.74^{e} (± 1.78)	66.61^{e} (± 2.79	65.67^{e} (± 2.46)
	Indigenous Breeds	OV	68.69^{de} (± 4.35)	64.40^{e} (± 3.07)	66.54^{e} (± 4.21)
		PK	72.74^{d} (± 3.14)	72.62^{d} (± 4.88)	72.68^{d} (± 3.87)
		Mean	**76.27 (± 9.69)**	**76.64 (± 9.03)**	

[12] Row means with the same superscript do not differ significantly (P>0.05)
[a-e] Column means with the same subscript do not differ significantly (P >0.05)
HS=Hyline Silver; HB= Hyline Brown; LS= Lohman Silver; LB= Lohman Brown; PK= Potchefstroom Koekoek; NH=New Hampshire; BA= Black Australorp; OV= Ovambo.

Although commercial breeds had significantly (P<0.05) higher HDP % than dual and indigenous breeds, HDP % did not differ significantly within breed categories, in the dam house, during the first month. In the control house, Lohman-Silver had a significantly (P<0.05) higher HDP % than Hyline-Silver. Dual and indigenous breeds also had significantly lower HDP % than all commercial breeds. However, New Hampshire hens had significantly (P<0.05) higher HDP % than Ovambo hens. In terms of the effect of housing system, the Hyline-Silver breed had a significantly (P<0.05) higher HDP % in the dam house than the control house.

There were no significant differences in HDP % between commercial breeds in the two housing systems, during the second month of the trial. The HDP % for Black Australorp was significantly lower than that of other dual and indigenous breeds in the dam house, but differed only with that of the New Hampshire breeds in the control house. The housing system had an effect only on indigenous breeds where the HDP % was significantly higher in the dam house than the control house.

In both housing systems, the Hyline-Silver had a significantly (P<0.05) higher HDP % than the Hyline-Brown during the third month of the trial. No significant differences occurred between the HDP% of dual and indigenous breeds in the control house, but Potchefstroom Koekoek had a significantly (P<0.05) higher HDP% than Black Australorp in the dam house.
With the exception of Lohman-Brown in the control house, all commercial breeds had a significantly (P<0.05) higher HDP% than dual and indigenous breeds during the fourth month. Hyline-Brown had significantly (P<0.05) lower HDP% than Hyline-Silver and Lohman-Silver in the dam house while Hyline-Silver and Lohman-Silver had significantly (P<0.05) higher HDP% than other commercial breeds in the control house. The New Hampshire breed in the dam house had significantly lower HDP% than indigenous breeds but no differences were detected in HDP% of dual and indigenous breeds in the control house. There was no significant housing effect observed for all laying hens during the fourth month of the trial.

During the fifth month, with the exception of Hyline-Brown in the control house, all commercial breeds had significantly higher HDP% than dual and indigenous breeds. In both housing systems, the Lohman-Silver breed had significantly (P<0.05) higher HDP% than other commercial breeds except Lohman-Brown in the dam house. In both housing systems, Hyline-Brown had significantly (P<0.05) lower HDP% than other commercial breed and did not differ significantly (P>0.05) with Black Australorp. The HDP% for Potchefstroom Koekoek was significantly (P<0.05) higher than that of dual breeds in the dam house, while both Potchefstroom Koekoek and Black Australorp had significantly higher HDP% than New Hampshire and Ovambo breeds in the control house. No significant housing system effect occurred for hen day egg production % of laying hens during the fifth month.

4.1.10. Body weight

The effect of breed and housing system on body weight of laying hens over different trial periods is depicted in Table 4.10.

Table 4.10 The effect of housing system and breed on the body weight (g) of laying hens (± standard deviation)

Period/3mths	Type	Breeds	Housing system		Mean body weight for breed
			Dam house	Control house	
Trial commencement	Commercial Breeds	HB	1.94 (± 0.10)	1.78 (± 0.10)	1.86 (± 0.12)
		HS	1.94 (± 0.08)	1.80 (± 0.08)	1.87 (± 0.11)
		LB	2.00^{1} (± 0.14)	1.76^{2} (± 0.08)	1.88 (± 0.17)
		LS	2.03 (± 0.10)	1.91 (± 0.04)	1.97 (± 0.10)
	Dual purpose Breeds	BA	2.82^{1} (± 0.13)	2.43^{2} (± 0.14)	2.62 (± 0.24)
		NH	2.45 (± 0.13)	2.36 (± 0.06)	2.41 (± 0.11)
	Indigenous Breeds	OV	2.09 (± 0.27)	2.06 (± 0.05)	2.08 (± 0.18)
		PK	2.08 (± 0.15)	1.97 (± 0.13)	2.03 (±0.16)
		Mean	**2.17 (± 0.32)**	**2.02 (± 0.26)**	
Mid-trial	Commercial Breeds	HB	1.91 (± 0.10)	1.80 (± 0.09)	1.86 (± 0.11)
		HS	1.85 (± 0.09)	1.81 (± 0.06)	1.83 (± 0.07)
		LB	1.98^{1} (± 0.11)	1.76^{2} (±0.12)	1.87 (± 0.14)
		LS	1.97 (± 0.09)	1.95 (± 0.06)	1.96 (± 0.07)
	Dual purpose Breeds	BA	2.58 (± 0.24)	2.50 (± 0.16)	2.54 (± 0.20)
		NH	2.48 (± 0.12)	2.39 (± 0.14)	2.43 (± 0.13)
	Indigenous Breeds	OV	2.04 (± 0.20)	2.08 (± 0.10)	2.06 (± 0.15)
		PK	2.04 (± 0.11)	1.95 (± 0.08)	1.99 (± 0.10)
		Mean	**2.11 (± 0.29)**	**2.04 (± 0.28)**	
Ending-period	Commercial Breeds	HB	1.94 (± 0.11)	1.82 (± 0.11)	1.88 (± 0.12)
		HS	1.91 (± 0.09)	1.79 (± 0.06)	1.85 (± 0.10)
		LB	1.97^{1} (± 0.12)	1.72^{2} (± 0.04)	1.84 (± 0.16)
		LS	1.98 (± 0.11)	1.85 (± 0.08)	1.91 (± 0.11)
	Dual purpose Breeds	BA	2.70^{1} (± 0.17)	2.44^{2}(± 0.12)	2.57 (± 0.19)
		NH	2.54 (± 0.09)	2.45 (± 0.07)	2.50 (± 0.09)
	Indigenous Breeds	OV	1.98 (± 0.26)	2.02 (± 0.11)	2.00 (± 0.19)
		PK	2.15^{1}(± 0.18)	1.90^{2} (± 0.10)	2.02 (± 0.19)
		Mean	**2.14 (± 0.32)**	**2.01 (± 0.28)**	

$^{1-2}$ Row means with the same superscript do not differ significantly (P>0.05)

HS=Hyline Silver; HB= Hyline Brown; LS= Lohman Silver; LB= Lohman Brown; PK= Potchefstroom Koekoek; NH=New Hampshire; BA= Black Australorp; OV= Ovambo.

The housing system influenced the body weight of Black Australorp and Lohman Brown hens which was significantly higher ($P<0.05$) in the dam house than in the control house at the commencement of the trial. All other breeds were not affected by the housing system on the body weight. During the mid-trial period only Lohman-Brown had a significantly higher ($P<0.05$) body weight in the dam house than in the control house. At the end of the trial-period the body weight of Black Australorp, Lohman-Brown and Potchefstroom Koekoek was significantly higher ($P<0.05$) in the dam house than at the control house.

4.1.11 Mortality

The effect of housing systems on mortality of laying hens from different breeds over the over 5 months trial period is described in Table 4.11.

Table 4.11 Effect of housing system and breed on mortality (%) of laying hens over 5 months period

Type	Breeds	Housing system		Mortality %
		Dam house	Control house	
Commercial breeds	HB	0	10	10
	HS	0	10	10
	LB	5	25	30
	LS	0	10	10
Dual purpose Breeds	BA	5	10	15
	NH	10	5	15
Indigenous Breeds	OV	5	0	5
	PK	0	5	5
	Mean%	**6.25%**	**10.71%**	**12.5%**

HS=Hyline Silver; HB= Hyline Brown; LS= Lohman Silver; LB= Lohman Brown;
PK= Potchefstroom Koekoek; NH=New Hampshire; BA= Black Australorp; OV= Ovambo.

The hens kept in the control house had a higher mortality rate than hens in the dam house. No mortalities occurred in the dam house for Hyline-Brown, Hyline-Silver, Lohman-Silver and Potchefstroom Koekoek. Only the Ovambo hens had no mortalities in the control house while Black Australorp, Hyline-Brown, Hyline-Silver and Lohman-Brown had higher mortality rates. It must be noted that 20% of the loss of Lohman-Brown hens in the control house was due to the theft.

4.2 Egg quality parameters

The results of egg quality parameters of the eggs of laying hens in different housing systems are presented in Tables 4.2.1- 4.2.5. The egg quality parameters were analyzed in laying hens with different ages, therefore it was important to look at the effect of breed in different housing system.

4.2.1 Albumen height

The effect of housing system on albumen height of eggs from laying hens of different breeds is depicted in Table 4.12.

Table 4.12 The effect of housing system and breed on albumen height (mm) of eggs (± standard deviation) from different laying hens

Interval	Types	Breeds	Housing system: Dam house	Housing system: Control house
1	Commercial Breeds	HB	7.26 (± 0.72)	7.23 (± 0.61)
		HS	6.50 (± 0.34)	6.52 (±1.03)
		LB	6.73 (± 0.37)	6.25 (±0.97)
		LS	5.57 (± 0.64)	5.78 (±0.61)
	Dual purpose Breeds	BA	4.06 (±2.39)	3.49 (±2.06)
		NH	4.82 (± 0.96)	5.61 (± 1.38)
	Indigenous Breeds	OV	4.51 (± 1.59)	4.03 (± 2.84)
		PK	5.70 (± 0.71)	5.97 (± 0.94)
2	Commercial Breeds	HB	6.47 (± 0.48)	5.83 (±0.72)
		HS	5.02 (± 0.77)	5.32 (± 1.81)
		LB	5.11 (± 0.68)	5.44 (± 0.91)
		LS	4.47 (± 0.86)	4.68 (± 0.66)
	Dual purpose Breeds	BA	4.38 (± 0.91)	4.31 (± 1.02)
		NH	4.46 (± 0.77)	5.09 (± 0.54)
	Indigenous Breeds	OV	4.65 (± 1.54)	3.91 (± 1.09)
		PK	4.90 (± 0.65)	4.28 (± 4.28)
3	Commercial Breeds	HB	8.18 (± 0.66)	8.18 (± 0.42)
		HS	7.47 (± 1.05)	7.02 (± 0.73)
		LB	7.35 (± 0.40)	7.74 (± 0.99)
		LS	7.34 (± 0.89)	6.92 (± 0.87)
	Dual purpose Breeds	BA	6.84 (± 1.07)	6.28 (± 0.80)
		NH	6.28 (± 1.15)	5.41 (± 3.23)
	Indigenous Breeds	OV	6.36 (± 1.78)	5.91 (± 0.90)
		PK	6.37 (± 0.34)	6.77 (± 0.65)
4	Commercial Breeds	HB	4.92 (± 0.20)	5.18 (± 0.50)
		HS	4.41 (± 0.33)	4.25 (± 0.59)
		LB	4.07 (± 0.44)	4.85 (± 1.10)
		LS	3.69 (± 0.56)	3.88 (± 0.62)
	Dual purpose Breeds	BA	2.82 (± 0.75)	2.53 (± 0.91)
		NH	2.73 (± 0.72)	2.99 (± 0.83)
	Indigenous Breeds	OV	1.81 (± 0.77)	2.63 (±0.96)
		PK	2.50[1] (± 0.97)	3.44[2] (± 0.48)

[1-2] Row means with the same superscript do not differ significantly (P>0.05)
HS=Hyline Silver; HB= Hyline Brown; LS= Lohman Silver; LB= Lohman Brown;
PK= Potchefstroom Koekoek; NH=New Hampshire; BA= Black Australorp; OV= Ovambo.

There was no significant difference in albumen height of eggs between the breeds except on Potchefstroom Koekoek in the fourth interval, which had significantly lower albumen height in the dam house than in the control house.

4.2.2. Haugh unit

The effect of housing system and breed on Haugh units of eggs produced by laying hens is depicted in Table 4.13

Table 4.13 The effect of housing system and breed on Haugh units of eggs from laying hens (± standard deviation)

Interval	Types	Breeds	Housing system	
			Dam house	Control house
1	Commercial Breeds	HB	83.19 (± 5.18)	82.32 (± 4.08)
		HS	80.23 (± 2.46)	79.95 (± 6.06)
		LB	80.09 (± 3.92)	77.92 (± 7.98)
		LS	73.07 (± 5.31)	73.80 (± 5.17)
	Dual purpose Breeds	BA	70.24 (±3.74)	66.25 (±3.18)
		NH	74.32 (±12.24)	72.88 (±11.92)
	Indigenous Breeds	OV	62.75 (±16.70)	67.70 (±12.47)
		PK	75.15 (± 7.05)	75.77 (± 7.02)
2	Commercial Breeds	HB	77.57 (± 1.92)	71.20 (± 9.12)
		HS	67.89 (± 7.66)	68.05 (±18.76)
		LB	68.18 (± 5.44)	71.41 (± 6.79)
		LS	63.75 (± 5.89)	64.74 (± 6.34)
	Dual purpose Breeds	BA	58.85 (± 9.39)	59.72 (± 9.99)
		NH	68.91 (± 8.37)	67.18 (± 4.19)
	Indigenous Breeds	OV	68.03 (±14.19)	71.69 (±9.96)
		PK	66.14 (± 7.14)	59.66 (±7.00)
3	Commercial Breeds	HB	87.56 (± 1.22)	90.08 (± 2.54)
		HS	83.97 (± 7.49)	82.99 (± 4.49)
		LB	85.73 (± 3.38)	86.87 (± 2.75)
		LS	85.13 (± 5.52)	82.72 (± 5.65)
	Dual purpose Breeds	BA	64.41 (±2.77)	71.52 (± 4.57)
		NH	84.68 (±5.92)	86.55 (±4.25)
	Indigenous Breeds	OV	62.52 (± 4.63)	68.73 (±7.43)
		PK	55.18 (± 6.83)	60.60 (± 6.61)
4	Commercial Breeds	HB	80.75 (± 4.53)	75.24 (± 4.97)
		HS	62.57 (± 4.56)	55.25 (±11.15)
		LB	54.71 (± 4.96)	57.95 (± 8.68)
		LS	63.79 (± 6.81)	59.02 (± 12.60)
	Dual purpose Breeds	BA	44.69 (± 4.83)	49.79 (±4.73)
		NH	44.37 (±16.65)	47.79 (±14.48)

	Indigenous Breeds	OV PK	63.33 (±10.67) 47.68 (± 6.91)	65.98 (± 7.73) 48.66 (± 5.47)

1-2 Row means with the same superscript do not differ significantly (P>0.05)
HS=Hyline Silver; HB= Hyline Brown; LS= Lohman Silver; LB= Lohman Brown; PK= Potchefstroom Koekoek; NH=New Hampshire; BA= Black Australorp; OV= Ovambo.

The breed and housing system did not affect Haugh unit of laying hens significantly.

4.2.3. Egg shell strength

The effect of housing system on egg shell strength of eggs produced by laying hens of different breeds is shown in Table 4.14

Table 4.14 The effect of housing systems and breed on egg shell strength (N) of laying hens (± standard deviation)

Interval	Types	Breeds	Housing system	
			Dam house	Control house
1	Commercial Breeds	HB	40.35 (±10.57)	34.60 (±8.47)
		HS	31.98 (± 1.64)	35.86 (±2.96)
		LB	41.58 (±7.72)	41.49 (±9.37)
		LS	41.96 (± 4.21)	39.97 (±7.58)
	Dual purpose Breeds	BA	43.57 (±18.74)	29.63 (± 20.35)
		NH	34.18 (±2.77)	37.05 (± 1.56)
	Indigenous Breeds	OV	36.06 (±10.80)	42.26 (± 7.87)
		PK	28.05 (± 9.73)	25.99 (±9.06)
2	Commercial Breeds	HB	30.28 (± 6.30)	28.07 (± 9.49)
		HS	30.53 (±10.62)	30.07 (±5.83)
		LB	37.80 (± 5.88)	36.21 (± 7.87)
		LS	42.71 (± 3.08)	39.72 (± 3.44)
	Dual purpose Breeds	BA	27.42 (±18.76)	27.99 (±18.41)
		NH	29.24 (±14.89)	29.07 (±4.20)
	Indigenous Breeds	OV	44.04 (± 10.73)	32.83 (±7.24)
		PK	42.23 (± 10.99)	37.70 (±12.44)
3	Commercial Breeds	HB	27.19 (± 5.21)	29.90 (± 3.52)
		HS	34.50 (± 5.81)	35.76 (± 4.22)
		LB	42.65 (± 2.93)	41.39 (± 6.92)
		LS	41.61 (± 2.19)	36.74 (± 6.32)
	Dual purpose Breeds	BA	34.29 (± 6.99)	36.30 (±3.13)
		NH	35.36^{1} (±4.89)	18.91^{2} (±14.27)
	Indigenous Breeds	OV	50.05 (±9.67)	40.25 (± 5.60)
		PK	37.61 (±8.76)	45.17 (± 4.55)

4	Commercial Breeds	HB HS LB LS	26.11 (±3.08) 26.37 (± 3.61) 34.78 (± 5.84) 40.51 (± 2.04)	28.14 (± 6.83) 26.86 (± 0.78) 30.19 (± 7.08) 40.89 (± 7.46)
	Dual purpose Breeds	BA NH	31.87 (±14.68) 26.85 (±8.32)	33.71 (±15.94) 29.57 (±14.56)
	Indigenous Breeds	OV PK	34.71 (±11.37) 41.07 (±7.12)	31.06 (±10.03) 28.25 (± 5.14)

1-2 Row means with the same superscript do not differ significantly (P>0.05)
HS=Hyline Silver; HB= Hyline Brown; LS= Lohman Silver; LB= Lohman Brown; PK= Potchefstroom Koekoek; NH=New Hampshire; BA= Black Australorp; OV= Ovambo.

The egg shell strength of eggs from New Hampshire hens was significantly (P<0.05) lower in the dam house than the control house during the third interval.

4.2.4. Specific gravity

The effect of housing system on specific gravity of eggs produced by different breeds in different housing systems is Table 4.15

Table 4.15 The effect of housing system and breed on specific gravity (g/cm^3) of eggs from laying hens (± standard deviation)

Interval	Types	Breeds	Housing system	
			Dam house	Control house
1	Commercial Breeds	HB HS LB LS	1.087 (±0.003) 1.085 (± 0.485) 1.089 (± 0.002) 1.089 (± 0.000)	1.087 (± 0.003) 1.0830 (±0.484) 1.087 (± 0.002) 1.090 (± 0.000)
	Dual purpose Breeds	BA NH	1.081 (± 0.002) 1.082 (± 0.003)	1.083 (± 0.002) 1.084 (± 0.003)
	Indigenous Breeds	OV PK	1.085 (± 0.003) 1.083 (± 0.003)	1.083 (± 0.003) 1.084 (± 0.004)
2	Commercial Breeds	HB HS LB LS	1.084 (± 0.001) 1.086 (± 0.002) 1.086 (± 0.002) 1.087 (± 0.002)	1.082 (± 0.006) 1.087 (± 0.002) 1.085 (± 0.002) 1.088 (± 0.002)
	Dual purpose Breeds	BA NH	1.079 (± 0.002) 1.079 (± 0.483)	1.083 (± 0.484) 1.081 (± 0.004)
	Indigenous Breeds	OV PK	1.077[1] (± 0.596) 1.080 (± 0.003)	1.086[2] (± 0.004) 1.080 (± 0.006)
	Commercial Breeds	HB HS LB LS	1.085 (± 0.003) 1.087 (± 0.003) 1.087 (± 0.004) 1.087 (± 0.002)	1.086 (± 0.004) 1.088 (± 0.002) 1.088 (± 0.002) 1.089 (± 0.487)

3	Dual purpose Breeds	BA NH	1.084 (± 0.005) 1.083 (± 0.593)	1.084 (± 0.484) 1.084 (± 0.003)
	Indigenous Breeds	OV PK	1.088 (± 0.485) 1.085 (± 0.003)	1.086 (± 0.486) 1.087 (± 0.003)
4	Commercial Breeds	HB HS LB LS	1.090 (± 0.000) 1.088 (± 0.002) 1.090 (± 0.000) 1.090 (± 0.000)	1.089 (± 0.003) 1.090 (± 0.000) 1.087 (± 0.003) 1.089 (± 0.002)
	Dual purpose Breeds	BA NH	1.088 (± 0.004) 1.087 (± 0.486)	1.087 (± 0.004) 1.089 (± 0.002)
	Indigenous Breeds	OV PK	1.080 (± 0.593) 1.085 (± 0.004)	1.090 (± 0.486) 1.087 (± 0.486)

[1-2] Row means with the same superscript do not differ significantly (P>0.05)
HS=Hyline Silver; HB= Hyline Brown; LS= Lohman Silver; LB= Lohman Brown; PK= Potchefstroom Koekoek; NH=New Hampshire; BA= Black Australorp; OV= Ovambo.

The specific gravity of Ovambo breed was significantly (P<0.05) lower in the dam house than the control house during the second interval. There was no effect of housing system in specific gravity for all other breeds throughout all the intervals.

4.2.5. Meat and blood spots

The effect of housing system and breed on meat and blood spots in eggs of laying hens is depicted in Table 4.16

Table 4.16 The effect of housing system and breed on meat and blood spots in eggs produced by laying hens (± standard deviation)

Interval	Types	Breeds	Housing system	
			Dam house	Control house
1	Commercial Breeds	HB HS LB LS	0.10 (± 0.14) 0.30 (±0.21) 0.45 (± 0.21) 0.25 (± 0.31)	0.20 (± 0.21) 0.40 (± 0.29) 0.25 (± 0.31) 0.35 (± 0.29)
	Dual purpose Breeds	BA NH	0.15 (± 0.14) 0.15 (± 0.14)	0.10 (± 0.14) 0.15 (± 0.22)
	Indigenous Breeds	OV PK	0.15 (± 0.22) 0.25 (± 0.18)	0.10 (± 0.22) 0.30 (± 0.27)
2	Commercial Breeds	HB HS LB LS	0.25 (± 0.11) 0.25 (± 0.14 0.55 (± 0.29) 0.50 (± 0.21	0.02 (± 0.11) 0.15 (± 0.14) 0.35 (± 0.29) 0.45 (± 0.21)
	Dual purpose Breeds	BA NH	0.20 (± 0.29 0.25 (± 0.25)	0.35 (± 0.29) 0.25 (± 0.25)

	Indigenous Breeds	OV PK	0.20 (± 0.29) 0.45 (± 0.21)	0.35 (± 0.29) 0.20 (± 0.21)
3	Commercial Breeds	HB HS LB LS	0.15 (± 0.14) 0.30 (± 0.21) 0.50 (± 0.25) 0.25 (± 0.18)	0.25 (± 0.25) 0.45 (± 0.21) 0.25 (± 0.25) 0.25 (± 0.18)
	Dual purpose Breeds	BA NH	0.40 (± 0.34) 0.15 (± 0.14)	0.15 (± 0.22) 0.20 (± 0.21)
	Indigenous Breeds	OV PK	0.15 (± 0.14) 0.35 (± 0.42)	0.35 (± 0.14) 0.25 (± 0.25)
4	Commercial Breeds	HB HS LB LS	0.25 (± 0.18) 0.50 (± 0.31) 0.45 (± 0.27) 0.55 (± 0.21)	0.45 (± 0.41) 0.50 (± 0.35) 0.40 (± 0.29) 0.50 (± 0.18)
	Dual purpose Breeds	BA NH	0.25 (± 0.25) 0.20 (± 0.21)	0.35 (± 0.29) 0.30 (± 0.21)
	Indigenous Breeds	OV PK	0.30 (± 0.21) 0.40 (± 0.14)	0.45 (±0.21) 0.50 (± 0.18)

[1-2] Row means with the same superscript do not differ significantly (P>0.05)
HS=Hyline Silver; HB= Hyline Brown; LS= Lohman Silver; LB= Lohman Brown; PK= Potchefstroom Koekoek; NH=New Hampshire; BA= Black Australorp; OV= Ovambo.

The housing system did not influence the occurrence of meat and blood spots in eggs of laying hens of different breeds.

4.3 Economic efficiency of laying hens from different breeds in two different housing systems

Economic performance of laying hens was measured by subtracting the total cost of layers and feed from the total income of egg and spent layer sales, as described by Das *et al.* (2003).

Table 4.17 Economic efficiency of poultry layer production using commercial breeds compared with indigenous and dual purpose breeds

4.3.1 Expenditure

1.Breed	Number of birds/breed	Unit price/layer	Total cost
Hyline-Brown	40	@R41.38/hen	1655.28
Hyline-Silver	40	@R48.10/hen	1924.00
Lohman-Brown	40	@R45.60/hen	1824.00
Lohman-Silver	40	@R45.60/hen	1824.00
Black Australorp	40	@R30/hen	1200.00
New Hampshire	40	@R30/hen	1200.00

Potchefstroom Koekoek Ovambo	40 40	@R30/hen @R30/hen	1200.00 1200.00
Total chicks cost			**R12027.28**
2. Breed	**Number of feed bags/breed**	**Unit price/ bag**	**Cost/breed**
Hyline-Brown Hyline-Silver Lohman-Brown Lohman-Silver	17.90bags 17.90bags 15.92 bags 17.90 bags	@ R181.00/50kg bag @ R181.00/50kg bag @ R181.00/50kg bag @ R181.00/50kg bag	3239.90 3239.90 2881.52 3239.9
Black Australorp New Hampshire	17.99 bags 17.81 bags	@ R181.00/50kg bag @ R181.00/50kg bag	3256.19 3223.61
Potchefstroom Koekoek Ovambo	17.36 bags 17.71 bags	@ R181.00/50kg bag @ R181.00/50kg bag	3142.16 3205.51
Total feed cost			**R25428.24**
Total expenditure (feed + chickens)			**R37455.97**

4.3.2 Income

1. Spent layers	**Number of birds sold/breed**	**Unit price/ hen**	**Income/breed**
Hyline-Brown Hyline-Silver Lohman-Brown Lohman-Silver	38 38 34 38	@R30 @R30 @R30 @R30	R1140 R1140 R1020 R1140
Black Australorp New Hampshire	37 37	@R30 @R30	R1110 R1110
Potchefstroom Koekoek Ovambo	39 39	@R30 @R30	R1170 R1170
Total income of layers			**R 9 000**
2.Eggs sold /breed	**Number of eggs/size/breed**	**Price/30eggs/size**	**Income/breed/ egg size**
Hyline-Brown Medium Large X-Large Jumbo	 156 2579 1392 110	 @ R32.00/30eggs @R28/30eggs @ R38.99/30eggs @R40/30eggs	 R166.40 R2407.07 R1809.13 R146.67 **R4529.27**
Hyline-Silver Medium Large X-Large	 968 3283 437	 @ R32.00/30eggs @R28/30eggs @ R38.99/30eggs	 R1032.53 R3064.13 R567.95 **R4664.61**
Lohman-Silver Medium	 935	 @ R32.00/30eggs	 R997.30

Large	3269	@R28/30eggs	R3051.06
X-Large	431	@ R38.99/30eggs	R560.16
			R4608.52
Lohman-Brown			
Medium	156	@ R32.00/30eggs	R166.40
Large	2699	@R28/30eggs	R2519.06
X-Large	905	@ R38.99/30eggs	R1176.2
Jumbo	76	@R40/30eggs	R101.33
			R3962.99
Black Australorp			
Medium	173	@ R32.00/30eggs	R184.53
Large	1938	@R28/30eggs	R1808.80
X-Large	173	@ R38.99/30eggs	R224.84
			R2218.17
New Hampshire			R69.33
Medium	65	@ R32.00/30eggs	R1766.80
Large	1893	@R28/30eggs	R83.18
X-Large	64	@ R38.99/30eggs	**R1919.31**
Potchefstroom Koekoek			
Medium	548	@ R32.00/30eggs	R584.53
Large	1989	@R28/30eggs	R1856.40
X-Large	157	@ R38.99/30eggs	R204.05
			R2644.98
Ovambo			
Medium	214	@ R32.00/30eggs	R228.27
Large	1882	@R28/30eggs	R1756.53
X-Large	514	@ R38.99/30eggs	R668.03
			R2652.83
Total income of eggs			**R27200.68**
Total income (eggs + spent layers)			**R32872.52**

4.3.3 Profit

Breed	**Income/breed(egg + spent layer)**	**Expenditure/breed (feed + layer cost)**	**Profit/Breed (income – expenditure)**
Hyline-Brown	R5669.27	R4895.18	R774.09
Hyline-Silver	R5804.61	R5163.61	R640.71
Lohman-Brown	R4982.99	R4705.52	R277.47
Lohman-Silver	R5748.52	R5063.9	R684.62
Black Australorp	R3328.17	R4456.19	-R1128.02
New Hampshire	R3029.31	R4423.61	-R1394.3
Potchefstroom Koekoek	R3783.25	R4342.16	-R558.91
Ovambo	R3854.57	R4405.51	-R550.94
Total	**R32872.52**	**R37455.97**	**R2376.89**

In terms of economic efficiency of the different breeds, commercial breeds were more profitable than all the other breeds. The dual purpose and indigenous breeds showed a negative profit. All the breeds were bought at different prices from different suppliers and were sold as spent layers after production at the same price. More eggs were sold from commercial breeds than dual purpose and indigenous breeds.

CHAPTER 5

Discussion

The type of housing system can affect production of laying hens (Reiter and Kurtz, 2001). In a study of integrated duck-cum-fish farming in Bangladesh egg production was adversely affected by storms and heavy rains (Latif *et al.,* 1993). Edwards *et al.* (1983) also reported poor laying rates during the rainy season and in very hot weather in Thailand. In the current study, the overall egg production did not differ between housing systems. However, breed and house interactions were observed only in the Ovambo breed during the first month where hens in the dam house produced more eggs than those in the control house. This confirms the results reported by Little and Satapornavit (1995) showing that confining poultry next to or over water can also improve their productivity under tropical conditions. During the second month both Potchefstroom Koekoek and Ovambo hens produced more eggs in the dam house than in the control house. This could be attributed to the adaptation of these two breeds in the second month and the more favourable environmental conditions in the dam house during very hot days, thus improving their production (Falayi, 1998).

As expected, the commercial breeds produced more eggs than the dual-purpose and indigenous breeds, of which the Potchefstroom Koekoek performed the best. This is in agreement with studies by Prinsloo *et al.* (1999) who reported high total egg production for Hyline Silver kept in in an integrated chicken-fish farming systems in Limpopo Province, South Africa. Singh *et al.* (2009) reported that Lohman White and Lohman Brown hens produced more eggs than non-commercial crosses between Rhode Island Red and Barred Plymouth Rock. Roushdy *et al.* (2008) also reported higher egg production by Hyline commercial chickens than Fayoumi and Dandarawi breeds (Egyptian native breeds). The genetic superiority of commercial breeds is also illustrated in ducks (Edwards, 1983; Sharma, 1989; Latif *et al.*, 1993; Das *et al.*, 2003). The results of this study are in agreement with the study by Van Marle-Koster and Casey (2001) showing the higher egg production over a production cycle of 51 weeks by Potchefstroom Koekoeks compared to Naked Neck, Venda and Ovambo hens, all kept in a battery cage system. Similar results were also reported by Grobbelaar *et al.* (2010) for a 52 weeks production cycle in a floor system. This confirms the high egg production potential of Potchefstroom Koekoek hens amongst the South African indigenous breeds, which are known for its lower egg production.

Breed and month interactions were observed in the dam house on Potchefstroom Koekoek hens during the second, third, fourth and fifth months of the trial, where their egg production did not differ significantly with that of the commercial breeds. Egg production for Potchefstroom Koekoek differed to that of the Ovambo hens during the fourth and fifth months. Theimsiri (1992) suggested that evaporative cooling water from the pond can reduce heat stress in broilers, which can increase egg production in laying hens. Hyline-Brown produced fewer eggs than other breeds during the fourth month while Black Australorp hens produced the least among all the breeds. The lower egg production of these breeds might be due to the heat stress in the control house that caused lower feed intakes and subsequently lower egg production.

The results of the current study indicated that the egg weights of laying hens were not affected by the housing systems over the five month trial period. Egg weight is influenced by the breed of laying hens (Halaj *et al.*, 1998). Moula *et al.* (2009) also reported lower egg weights for the Ardennaise and Famennoise (indigenous) breeds compared to the Lohman strain (commercial). Commercial breeds produced heavier eggs than the indigenous breeds, although within breed differences occurred between brown and white lines. The brown lines in this study produced heavier eggs than the white lines which are in line with Preisinger (2000) reporting Lohman-Brown strains with heavier eggs of 65.4g than Lohman-White strains with lighter eggs of 63.1g. The heavier egg weight of the brown lines is due to the selection for this trait by the breeders.

The lower egg weight of indigenous hens in this study is in line with the results by Adetayo and Babafunso (2001) reporting that the mean egg mass of the Nigerian indigenous chickens was 36.8g. Gueye (1998) also reported that the mean egg mass of the indigenous chickens in Ethiopia was 40g using an intensive system during trials conducted at the Jimma College of Agriculture. Furthermore, Nhleko *et al.* (2003) also reported that the mean mass of eggs collected from indigenous chickens from subsistence households in the rural district of Paulpietersburg, north-eastern Kwazulu-Natal, South Africa, was 48.9g while Iqbal *et al.* (2009) reported egg weights of indigenous chickens of Kashmir in India of 46.06g. However, contrasting results were reported for ducks by Das *et al.* (2003) where similar egg weights were observed between commercial and indigenous duck breeds kept in an integrated fish farming system. Our results also indicated that Potchefstroom Koekoek hens produced heavier eggs than Ovambo and dual purpose hens.

The monthly variations in egg weights of laying hens in different housing systems observed in this study could be due to the late sexual maturity of the indigenous breeds (Melesse *et al.*, 2010), or selection for high egg weight in the commercial breeds. However, egg weight is said to be largely affected by environmental factors, food restriction and parental average body weight (Shaler and Pasternak, 1993). Differences in the current study could therefore be attributed to these factors but evidence of genetic involvement including breed effect could also be observed.

The results showed that housing systems and breed did not affect feed intake of laying hens in the current study throughout the whole trial period. Das *et al.* (2003) reported that the Indian runner (IR), Khaki Campbell (KC) and Zending (Z) ducks in integrated fish-duck farming systems were fed the same diet at 115g/duck/day and no significant differences in feed intake were observed between breeds. In the current study, laying hens were given the same feed at 150g/hen/day and all breeds finished all the feed in both housing systems. However, most studies reported a significant effect of housing systems on feed intake of laying hens (Yakubu *et al.*, 2007). Farooq *et al.* (2002) also stated that feed intake is a variable phenomenon and is influenced by several factors such as strain of the bird, energy content of the diet, ambient temperature, density of birds in the shed, hygienic conditions and rearing environment.

The results of the current study indicated a strong relationship between egg weight and feed efficiency in commercial breeds, as they ate more feed and produced heavier eggs which mean they converted feed efficiently. Although all the breeds had the same high feed intakes, the indigenous and dual purpose breeds had poor conversion efficiencies possibly because of genetic differences in physical activity, physical condition, basal metabolic rate, body temperature and body composition (Singh *et al.*, 2009).

Feed conversion can be influenced by the housing system. Feed conversion is poorer in aviary and free range systems than in cages (Hughes *et al*., 1985; Van Horne and Van Niekerk, 1998). In alternative housing systems, hens have to use some of their energy for heat production (Preisinger, 2000) and movement, because of lower stocking densities and sometimes lower temperatures in these systems. This leads to higher feed consumption and unfavorable feed conversion. The differences in feed conversion ratio is related to the strain, possibly because of the genetic differences in the physical activity, physical condition, basal metabolic rate, body temperature and body composition (Singh *et al*., 2008). In the current study, the FCR of Black Australorp hens were poorer in the dam house than in the control house during the five month trial period. This could be attributed to the unfavourable climatic conditions in the dam house. In contrast, Ovambo hens had a better FCR in the dam house than at the control house during the five month trial period which is in agreement with previous studies by Barash *et al*. (1982) and Falayi (1998) who reported a better feed conversion ratio on ducks integrated with fish than those on land. The authors further explained that the environmental condition of the house on top of the dam improved performance of ducks due to the evaporative cooling and cleanness of water from the integrated fish farming system. The results of the current study are supported by the findings of Falayi (1998). A better FCR was also reported in the study by Das *et al*. (2003) on three different duck genotypes integrated with fish.

During the first month, FCR of the dual purpose breeds and Ovambo breed on the dam was poor compared to the control house. In this case, it could be that the dual purpose and Ovambo breeds did not utilise the feed consumed efficiently for egg production. However, according to Little and Satapornavit (1995), these hens might have pecked more on their feed than other breeds so that more of the feed got spilled over the dam water. The commercial breeds had a better FCR than all the other breeds, both in the dam house and also in the control house. This could be due to their genetic potential of efficiently converting their feed consumed into eggs.

During the second month, FCR was poor for Black Australorp at the dam house than at the control house. It shows that the breed was performing not as good under the integrated farming system (dam house) than at the control house during this month. Literature is not available to support this finding. The inverse occurred in the Potchefstroom Koekoek with a better FCR at the dam than control house due to environmental conditions that was more favourable for the breed to be productive. During the third month, the commercial breeds also had a better FCR than all the other breeds in both housing systems.

During the fourth and fifth months the FCR of the commercial breeds was better than all the other breeds. However, better conversion ratios in indigenous chicken have been reported in cases where they were provided with commercial feeds (Kingori *et al*., 2003).

The commercial breeds had higher HDP % than all the other breeds throughout the trial. This is due to their higher genetic potential for egg production. The current result is supported by Farooq *et al*. (2002) reporting that strain of the chicken and rearing system had a significant effect on hen-day egg production percentage. The above authors reported that Hisex was more persistent in percentage hen-day production percentage than Nick-chick. Differences in hen-day egg production percentage among various strains of chicken were also reported by North (1984) and Lai and Kan (2000).

During the first month HDP% of Hyline-Silver and the indigenous breeds during the second month was higher at the dam house than at the control house, probably because the environment was favourable for the breeds to be more efficient in production. The result of the current study is in line with the findings of Rashed Hasnath (2002). However, studies by Badudi and Ravindran (2004) demonstrated a strong and positive correlation between daily feed intake and hen day production.

The results of the current study showed that Lohman-Brown hens in the dam house had higher body weights during all three periods of the study than those in the control house. The Potchefstroom Koekoeks showed similar trends at the end of the trial. This shows that these breeds were adjusting well in the dam house and that the environment at the dam house was conducive for the laying hens, which improved body weight (Little and Satapornavit, 1995). These results are in agreement with the study by Barash *et al*. (1982) who reported that ducks integrated with fish over the pond had higher body weights than the ducks in a normal system on land. Koeypudsa *et al*. (2005) also reported an increased body weight for broilers in a dam house (from 1.32kg ± 0.19 to 4.22kg ± 0.48 $x10^3$) compared to broilers in a control house which increased their weights from 1.33kg ± 0.20 to 3.64kg ± 0.57 x 10^3. In contrast Das *et al*. (2003) reported a similar body weight gain in three different duck genotypes in integrated duck-fish farming system.

The results of the current study shows a lower percentage of mortality in laying hens kept in an integrated chicken-fish farming system than in a battery cage system on land. This could be due to the conducive and favourable environmental conditions for laying hens at the dam house than the control house. The current result is supported by Barash *et al*. (1982) who reported a lower 3.5% increase in mortality rate of ducks in integrated duck-fish farming system than ducks kept in pens. Prinsloo and Schoombie (1999) also reported zero mortality of Hyline-Silver hens in a 200 days period in the production of poultry in integrated aquaculture agriculture systems trial with no control. However, the results by Das *et al*. (2003) indicated a similar mortality rate for different duck genotypes in integrated duck-fish farming system without a control.

There is limited information on egg quality of laying hens in integrated fish farming systems. The Haugh unit is an expression relating egg weight and height of thick albumen. The higher the Haugh unit, the better the egg quality. Egg quality has a genetic basis and its parameters vary between strains of hens (Silversides *et al*., 2007) and is also influenced by the housing system under which the hens are kept (Vits *et al*., 2005; Sekeroglu *et al*., 2010). The results of the present study showed no significant effect of housing systems on egg quality parameters of laying hens i.e. albumen height, Haugh unit, specific gravity, shell strength, as well as blood and meat spots. The results of this study are in line with the report by Englmaierová and Tumanová (2009).

Finally, the commercial breeds provided a higher profit from egg sales and spent layers income compared to indigenous and dual purpose breeds. In general, Potchefstroom Koekoek showed the potential to produce more eggs than the other dual purpose and indigenous breeds, which is in agreement with reports by Van Marle-Koster and Casey (2001) and Grobbelaar *et al*. (2009).

Conclusion

The main objective of the study was to identify the best performing chicken layer breed for an integrated fish farming system. The hypothesis of this study was that the production performance of different laying hens kept under integrated layer-fish farming system and conventional battery cage will not differ.

The first objective was to compare the egg production, body weight, mortality rate, feed conversion ratio, feed intake and hen-day production % of different layer breeds kept under an integrated fish farming system with those kept in a normal battery system situated on land. Results of this study showed that the type of housing affected the performance of some breeds of layers over time. It is concluded that commercial breeds had superior performance compared to dual and indigenous breeds for most variables, such as egg production, egg weight, FCR and HDP%.

In terms of body weight, Black Australorp and Potchefstroom Koekoek had higher body weights in the dam house than control house, indicating that higher carcass weight per kilogram will be attained thus increasing profit when selling spent hens. It is concluded that this parameter will enhance viability of the integrated fish and chicken production systems.

The second objective was to compare the egg quality of eggs from layer breeds kept under an integrated fish farming system with those kept in a normal battery system. In contrast to other results, Potchefstroom Koekoek hens had significantly lower albumen height than all the other breeds, in the dam house. It is concluded that eggs from this breed will have shorter shelf life than those of other breeds, under the integrated systems.

Only New Hampshire hens showed lower egg shell strength in the dam house than control house. It is therefore concluded that the eggs of this breed may be more susceptible to cracking when used in an integrated fish and chicken production system which might result in an economic loss.

The third objective was to determine the economic efficiency of the different chicken layer breeds. The commercial breeds gave the highest economic returns and were followed by the Potchefstroom Koekoek. This indigenous breed can therefore be regarded as the most economically viable among the different dual and indigenous breeds for use in integrated fish farming system.

The null hypothesis that the performance of different breeds in two housing systems do not differ is therefore rejected, and the alternate hypothesis that one or more laying hens are more suitable for use in an integrated fish farming system is accepted.

Recommendations

It is recommended that the commercial breeds be used in integrated fish farming system because of its economic viability and returns. It is also recommended that the layer chicken breed that can be used under integrated chicken-fish farming system should be a breed that can realise the highest profit to add on the economic viability of the whole integrated chicken-fish farming system. It is recommended that the system needs proper skills and management for both farming enterprise for the profitability of the system. It is recommended that much more research is done on the Potchefstroom Koekoek's potential kept in intensive management systems. The dual and indigenous breeds should not be used in the integrated chicken fish farming system, because it proofed to be less profitable.