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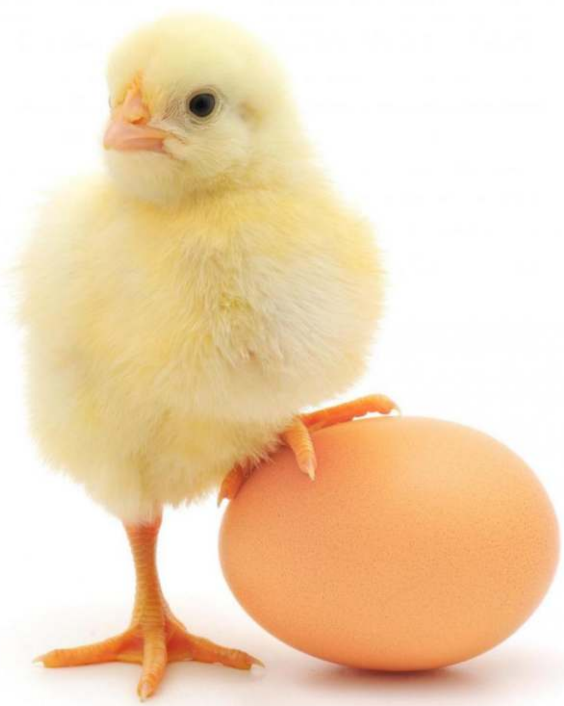

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Evaluation of the Growth Potential of Local Chickens in Malawi

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Abstract: The growth potential of local chickens in Malawi was evaluated by comparing their growth performance under cage-fed and free-range management conditions. Chicks (n = 106) were collected from 39 farmers in 19 villages and individually raised in cages from an average age of 9 weeks to 20 weeks. On-farm made growers mash (17% CP) was fed and birds were treated against common diseases and parasites. Hatch mates (n = 141) of cage-raised chicks remained on farmer household flocks and were raised by their dam hens under scavenging conditions. These birds were raised in two batches between October and December 2002, and between January and March 2003, which were corresponding with hot-dry and warm-wet seasons, respectively. Sex of chickens, village, management and management x batch interaction significantly ($p<0.05$) influenced growth traits. The values for birds under cage-managed conditions were significantly ($p<0.05$) 27, 39, 42, 25 and 41% higher than for birds under scavenging conditions, for weight at 20 weeks, overall daily weight gains, specific growth rate and growth efficiency, respectively. Phenotypic variance for daily weight gains and specific growth rates were 17 and 21%, respectively lower for cage-fed than for free range birds. Correlation coefficients of growth traits measured between cage-fed and scavenging conditions were low ($r = 0.21-0.53$, $p<0.05$), indicating possible genotype by environment interaction. Gross margin over feed costs was MK26.00 per bird (SD, MK27.00). This was 35% rate of return on feed costs (SD = 38%) or 24% rate of return on initial bird value plus feed cost (SD = 26). It is concluded that growth potential of local chickens is only partially exploited under scavenging conditions primarily due to feed constraints.

Key words: Growth potential, cage fed, scavenging, local chickens

Introduction

The recognized importance of local chickens in providing meat, cash income, socio-cultural values to rural people and their efficient scavenging system has led to increased research on the species during the past 10 years. However, most of these studies have been baseline surveys and interviews (Pedersen, 2002). These studies have generated information on local chicken production, their functions to rural households and demonstrated that the system is complex with many constraints such as low productivity of meat and eggs, and high mortality (Guèye, 1998). Because of little or no investment into the system, production of local chickens is low cost, makes use of by-product resources and is thus efficient (Aini, 1990).

Growth is a compound trait influenced by genetic and management, especially nutrition and health. The village scavenging condition is variable, without standard husbandry system (Kitalyi, 1998). Performance of local chickens is thus also variable under traditional production system. While it is important to know how chickens perform under scavenging conditions, knowledge of their production potential is also essential (Pedersen, 2002). This knowledge can guide sound formulation of strategies to improve local chickens. Trials under controlled environments can help to determine production potential, especially when compared to the scavenging village conditions. The objectives of this study were to determine growth potential of local chickens under cage-managed system; and to compare their growth with local chickens under free-ranging system in the villages. The hypothesis to be tested was that the village free-ranging system limit expression of growth potential of local chickens.

Materials and Methods

Experimental site: This study was conducted at Bunda College of Agriculture (BCA) located 30 km west of Lilongwe. Fifty (50) metabolic cages of 34 x 33 x 33 cm size were constructed locally from welding wire and placed inside a building, which had open sides covered with wire mesh for ventilation. Each cage was fitted with water and feed troughs locally made from burnt clay and curved on top to minimize feed spillage.

The trial on scavenging conditions was conducted in the surrounding villages on households of farmers who participated in the village poultry project. These villages surround BCA, and are located within the coordinates 14.10^{o} S, 33.47^{o} E and altitude is approximately 1200 m above see level (Garmin GPSMAP 76CS, Garmin Ltd, www.garmin.com). Over the past four years, annual precipitation for Lilongwe averaged 932 mm (National

Statistical Office, 2003). Two seasons are distinct; a wet warm season (November to April) and a dry season (May to October). Most of the smallholder farmers belong to the *Chewa* tribe and practice subsistence agriculture in a crop-livestock integrated system. About 82% of these farmers own local chickens using free-range, scavenging low input-low output production system (Gondwe and Wollny, 2002). Different phenotypes and different age-groups scavenge together. Farmers erratically provide supplement feed to their chickens, mainly using maize bran (10.4% CP). Through community participation, farmers were vaccinating their chickens against Newcastle disease (NCD) using La sota live vaccine (1000 doses cloned, Lohmann Animal Health GmbH) at three monthly intervals, between May and December. Farmers shared the cost of the vaccine.

Experimental chickens in cages: Fifty growing chicks collected from farmers in the study area were individually allocated into the cages at random. From each farmer, up to three chicks from the same hen were randomly chosen. The hatch dates of these chicks and their mother hens were recorded. Chicks were of an average age of eight (8.5) weeks when introduced to cages. Chicks were tagged, sexed and phenotypically characterized. Initial weight was taken for each bird. In total, 39 farmers from 19 villages in the study area contributed to the study. The periods for the pre-trial and batches 1 and 2 were, respectively, August - September 2002; October - December 2002; January - March 2003. Each batch covered on average 12 weeks.

Feeding in cages: During the study period, chicks were offered on-farm formulated growers' mash (Table 1). Growers' mash was chosen since it is fed to commercial layer chicks during growing phase. Feed and water were offered *ad lib* in the cages.

Health management of chicks in cages: Birds in cages were treated against helminths (Piperazine from CAPS, Zimbabwe), coccidiosis (Amprolium from Netherlands) and other prophylaxis (Triple Sulfa from Antec Health care Africa Ltd, South Africa). Those that had external parasites were dusted and smeared with tick greeze (Cooper Ltd, Zimbabwe). Other treatments were administered upon noticing a problem on individual birds. Health was monitored on daily basis. Treatment was, however, administered to all birds to prevent possible infection to other birds.

If birds died during the study, it was arranged to return to farmers a replacement bird of similar age taken from the College stock.

Experimental chickens under free-range: The clutch mates of chicks (offspring from same hatch) brought to cages remained at the farmers' home in the villages. These were on free-range (scavenging) with their dam-hens. Their growth was monitored during the same period as their contemporary counterparts in cages. Weighing of all birds was on the same day on weekly intervals. Management followed what farmers practiced including the participatory communal Newcastle disease vaccination.

Data collected: Birds were in the cages until they reached 20 weeks of age. Altogether there were three batches of chicks introduced in the cages. However, the first batch was on pre-trial basis and was not be included in the analysis. With two batches, 100 chicks were observed. Of these, 70% were female and 30% males. Distribution in terms of colour[1] were 4.76% *Chiphulutsa,* 20.95% *Kawangi*, 12.38% *Mawanga,* 26.67% *Yakuda,* 15.24% *Yofira* and 20.00% *Yoyera*. On a weekly basis, live weights of chicks were taken using a digital scale (Ohaus CS5000, Ohaus Corp, Pine Brook, NJ, USA; maximum of 5 kg, graduated to 2 g).

Data on free-range birds (n = 147) were combined with data from cage birds and subjected to similar calculations described for cage-managed chickens pertaining to growth traits. Altogether, there were 247 birds included, 40% in cages and 60% under village management. Female birds constituted 71%. Distribution by batch is shown in Table 2.

Data calculation and analyses: Growth performance was determined using live weights and growth rate parameters weight gains, specific growth rates and growth efficiency. These were calculated as follows

$$WG = \frac{LW_{ti} - LW_{to}}{t_i - t_o} \quad (1)$$

Where, WG is weight gain (daily, weekly or overall) per time period in g; LW_{ti} is live weight at particular week = t_i; LW_{to} is live weight for the previous period = t_o

$$SGR = \frac{\ln(LW_{ti}) - \ln(LW_{to})}{t_i - t_o} * 100 \quad (2)$$

Where, SGR is the specific growth rate in percent growth per day at a particular time; $\ln(LW_{ti})$ is natural log of live weight at week = t_i; $\ln(LW_{to})$ is natural log of live weight at previous week = t_o; $(t_i\text{-}t_o)$ is the period of weighing converted to days

$$GE = \frac{WG_{ti}}{LW_{to}} \quad (3)$$

Where, *GE* is growth efficiency per time period = t_i; WG_{ti} is weight gain at time = t_i; LW_{to} is live weight at time = t_o

All measured and calculated parameters were tested for normality using proc univariate, normal and plot procedure of SAS (SAS, 1999). Normality was considered at over 90 % using Shapiro - Wilk (W) test for

Table 1: Ingredients and nutritive contents of growers' mash ration fed to chicks (on as fed basis)

Ingredient	Amount (kg/100kg)
Maize	67.61
Soybeans, full fat, roasted	26.12
Fish meal	3.67
Vitamin and Mineral premix	0.30
Iodised salt	0.30
DL-Methionine	0.01
Lime	2.00
Total	100.00
Nutrient contents[1]	
Dry matter, % (analyzed)	95.34
Crude Protein % (analyzed)	17.95
Calcium % (calculated)	1.00
ME, kcal per kg (calculated)	3233
Phosphorus % (calculated)	0.83
Crude Fibre, % (calculated)	2.43
Lysine % (calculated)	0.93
Methionine % (calculated)	0.32

[1]Analsyzed means nutrients were analyzed in the lab; calculated means nutrients were calculated based on nutrient values of ingredients.

Table 2: Distribution of chicks allocated into cages and on-farm with number of their hens

Batch	Number of hens	Number of chicks	
		Cage	On-farm
1	22	50	79
2	24	50	68
		100	147

normality (n_{obs} < 2000). All parameters were normally distributed and data analyses proceeded without transformations.

Model of analyses: The model of analysis included the management effect to compare growth variation among birds between cage-managed and free-range managed systems. Effects of colour, two-way (except batch x management) and three-way possible interactions were not significant (p>0.05) and were hence dropped from the model. Initial weight was more important as a covariate than initial age and hatch weights. All analyses were based on overall production in this case. The final model fit to data was

$$y_{ijklmn} = \mu + b_i + m_j + s_k + v_l + h_m + \beta(x_{ijklmn} - xn) + \xi_{ijklmn} \quad (4)$$

Where, y_{ijklmn} is the observed measure for bird n; μ is the overall mean to all birds; b_i is the fixed effect of batch of production (I = 1,2); m_j is the fixed effect of management (j = cage, scavenging); s_k is the fixed effect of sex of bird (k = 1,2); v_l is the fixed effect of village (l= 1,2 …, 19); β is the linear regression coefficient of the measure on initial weight of bird; (x_{ijklmn} - xn) is the observed initial weight of the n-th bird adjusted from the overall mean initial weight (xn), taken as a covariate; h_m is the random effect of hen; ξ_{ijklmn} is the residual error assumed NID (0, $\sigma^2\xi$).

Batches of production were confounded with season. Batch one was during hot-dry season and batch two in hot-wet season. Batch / seasonal effects will be used interchangeably.

Proc mixed REML procedure of SAS (SAS, 1999) was used during the analysis of variance for the various parameters. Least square means were separated into significant differences by the least significant difference procedure (LSD).

An estimate of genotype x environment (G X E) interaction was done by correlating performance of local chickens between two management systems based on dam-hen REML BLUP values obtained using proc mixed procedure of SAS (SAS, 1999).

Economic evaluation of feed costs: Feed costs (FC) during cages were calculated by multiplying total feed intake (TFI) by price per kg feed. Revenue (RV) was calculated by multiplying weight at 20 weeks per bird by farm-gate price of MK142.79 per kg live weight of chicken (price determined from participating farmers' selling prices for chickens). Initial value of chicken was calculated by multiplying initial weight per bird by farm-gate price per kg live weight. Gross margin over feed cost (GMOFC) was calculated by subtracting FC from RV. Return on FC was calculated as GMOFC as a percentage of FC, while return on bird and FC was calculated as GMOFC as a percentage of initial bird value plus FC. These parameters were normally distributed and were analyzed for their means and standard deviations. Analysis of variance was performed to test effect of batch and sex using general linear model procedure of SAS (SAS, 1999).

Results

Fixed effects of growth performance: Table 3 shows fixed factors and their effects on overall values for growth traits. Batch of production significantly (p<0.05) influenced SGR while sex of birds, village, management and management x batch interaction significantly (p<0.05) influenced more growth performance traits. Initial live weight was not significant (p>0.05) for overall and daily weight gain.

Growth performance between cage-fed and scavenging chicken mates: Birds under cage-fed condition were superior to clutch mates under free-range village conditions (Table 4). Based on overall values, birds under cage-fed management were significantly (p<0.05) 27.04, 39.01, 41.54, 25.25 and 41.18% superior than birds on free-range for live weights, overall weight gains, daily weight gains, SGR and GE, respectively.

Table 3: Effects of fixed factors on overall growth characteristics of local chickens under cage and free-range management

Effect	Weight at 20 weeks	Overall weight gain	Daily weight gain	SGR	GEF
Batch of production	ns	ns	ns	***	ns
Sex of birds	***	***	**	ns	*
Village	*	*	***	ns	ns
Management	***	***	***	***	***
Batch x management	*	*	*	*	ns
Initial weight	***	ns	ns	***	***

SGR = specific growth rate (% growth per day); GE = growth efficiency (g final weight gain / g initial weight); Significant levels (F – Test), * = p<0.05; ** = p<0.01; *** = p<0.001; ns = not significant (p>0.05)

Table 4: Overall productivity of local chickens under cage-fed and free – range village conditions (lsmeans and standard errors)

Trait	Batch	Management			
		Cage-fed		Free- range (villages)	
		Mean	SE	Mean	SE
Live weight (g) at 20 weeks	1	1131.85[a]	47.36	835.23[b]	49.37
	2	1022.04[a]	40.33	860.17[b]	46.98
	Overall	1076.94[a]	32.12	847.70[b]	34.55
Weight gain (g/period)	1	871.75[a]	47.36	575.13[b]	49.37
	2	761.94[a]	40.33	600.07[b]	46.98
	Overall	816.84[a]	32.12	587.60[b]	34.55
Daily weight gain (g/day)	1	10.68[a]	0.63	6.61[b]	0.66
	2	10.58[a]	0.53	8.41[b]	0.63
	Overall	10.63[a]	0.42	7.51[b]	0.46
SGR (% / day)	1	1.665[a]	0.119	1.167[b]	0.123
	2	2.045[a]	0.105	1.796[b]	0.116
	Overall	1.855[a]	0.087	1.481[b]	0.091
GE (g/initial weight)	1	3.471[a]	0.201	2.417[b]	0.209
	2	3.297[a]	0.169	2.377[b]	0.202
	Overall	3.384[a]	0.133	2.397[b]	0.146

SGR = specific growth rate (% growth per day); GE = growth efficiency (g final weight gain / g initial weight)

Variance components and G X E interaction: Effect of management was compared on behaviour of variance components as shown in Table 5. Management did not affect phenotypic variance for final weight and weight gains. Phenotypic variance for daily weight gains and SGR were 16.9 and 21.3%, respectively, lower for cage-fed than for free-range birds. On the other hand, phenotypic variance for GE was 7.8% higher in cage-fed than in free-range birds. The between dam-hen variance was larger in free-range birds than in cage-fed birds. The between dam-hen variance was also larger than the within bird variance comparing within free-range birds. Correlation coefficients between cage-fed and free-range local chickens (Table 6) were significantly (p<0.05) different from zero but lower than 50% for all traits except for daily weight gains. SGR had lowest coefficient.

Economic evaluation of feed costs in cages: Economic evaluation of feed costs (Table 7) showed a positive mean gross margin with a wide variation. Similarly, both rate of return on feed costs and on feed and bird costs showed wide variation. Batch and sex effects were not significant (p>0.05, Table 8)

Discussion

Growth potential: Demeke (2003) observed higher live weights (1300g, intensive; 985 g, free-range) in Ethiopian local chickens at 20 weeks of age than the results from this study. The difference could in part be due to different initial live weights, which were not adjusted for in Demeke's study. In this study, feeding started from 9 weeks while in Demeke's study, feeding started from one day old. However, daily weight gains are comparable. On the other hand, the trend for live weights and daily weight gains agree with those in this study, whereby their birds under intensive system were 24% heavier than birds under scavenging conditions.

Table 5: Variance components by management of local chickens for growth traits

Component		Weight at 20 weeks		Weight gain		Daily weight gain		SGR		GE	
		ó^2	SE	ó^2	SE	ó^2	SE	ó^2	SE	ó^2	SE
Between dam hen	Cage	12109	7114	12109	7114	0.8388	0.846	0.0366	0.022	0.2764	0.150
(ó^{2}b)	Free-range	25107	9404	25107	9404	4.2914	1.891	0.0835	0.050	0.5320	0.203
Within birds	Cage	24416	4426	24416	4426	4.9720	0.841	0.0956	0.017	0.5844	0.102
(ó$^2_{residual}$)	Free - range	11832	2206	11832	2206	2.7045	0.522	0.0845	0.017	0.2666	0.050
Total (ó^2_p)	Cage	36525		36525		5.8109		0.1322		0.8608	
	Free - range	36939		36939		6.9959		0.1680		0.7986	

SGR = specific growth rate (% growth per day); GE = growth efficiency (g final weight gain / g initial weight)

Table 6: Correlation coefficients between BLUP values of dam hens for cage fed and free - range managed local chickens

Trait	Weight at 20 weeks	Weight gain	Daily weight gain	SGR	GE
Coefficient	0.384	0.384	0.529	0.219	0.376
Significance level	**	**	***	*	*

SGR = specific growth rate (% growth per day); GE = growth efficiency (g final weight gain / g initial weight); Significant levels , * = $p<0.05$; ** = $p<0.01$; ***=$p<0.001$

The status and limitation of scavenging feed resource base is the main area of research in many countries in Africa (Roberts, 1999; Olukosi and Sonaiya, 2003). In their prediction, Olukosi and Sonaiya (2003) estimated a daily feed intake of 20 g per bird per day under scavenging condition, which was lower than feed intake observed in the study (45-59 g per day) under cage management. The findings support views that scavenging feed resource base is often inadequate quantitatively and qualitatively (Huque, 1999; Ndegwa *et al.*, 2001; Dana and Ogle, 2002), depending on flock size, environment and season (Gunaratne, 1999; Roberts, 1999). Kitalyi (1998) reported that scavenging feed is a constraint to local chicken growth and reproductive potential, and emphasized on the need to provide supplement feeds to birds. The major input to birds under cage management was feeding of balanced ration, grower's mash. Disease intervention may have differed in intensity (between cage-fed and village chickens) but was also taking place in the villages. The difference in growth performance observed in the study was therefore due to feeding management. The significant superiority of birds under cage managed conditions over village free-range birds shows that feed constraint limits expression of growth potential in local chickens.

The significant effect of village on final weight, and weight gains is probably due to differences in flock structure, management, scavenging biomass and nutritional pressure under free-range, and disease challenges that vary from village to village. Village effect was more pronounced in birds under free-range than those fed in cages. This is obvious since birds in cages were exposed to village conditions only before they were brought to cages.

Variance components: The larger between dam-hen variance for free-range than for cage-managed birds is expected since free-range birds continued with their dam-hens, and hence had more common influence from their dam-hens. Nature of data in this comparison did not allow for determining the between bird variance. Hence, the dam-hen variance includes all genetic, maternal and common environment effects. Since village effect was taken care of, the common environment in this case was flock of the birds. Birds under cage management were separated from their dam-hens, and hence the low between dam-hen variance that was in this case, a carry over effect.

Hu *et al.* (1999) reported that maternal effects are moderate in poultry, only contributing less than 10% of total variance and depend on traits. Falconer (1989) reasons that maternal affects are more important in mammals. Pinchasov (1991) reported that maternal effects in chickens disappear within the first three weeks of chicks life. Prado - Gonzalez *et al.* (2003) observed significant effect of maternal effect for weights at hatch and fourth week of Creole chickens in Mexico and not thereafter. The variances in this study show potential maternal effects that are high and persist for long time in chickens. Maternal effects from literature arose from the dam-hen influence on the egg (size, weight, shell quality and yolk composition) that is described as the only vehicle for maternal effects in poultry (Sewalent and Johansson, 2000). This is true when birds are raised under intensive system and are separated from their dam-hens at hatch. In free-ranging chickens, a dam-hen takes care of chicks till weaning, hence post hatch maternal effects are expected. The observed variance and the difference show possible post hatch maternal influence on the birds under free-range system. The magnitude of such maternal effect is however, trait and management specific.

Table 7: Descriptive statistics for economic parameters of feed costs for chickens under cage management

Parameter	n	Mean	SD	Minimum	Maximum
Total feed intake, g	100	3473.5	884.7	1048.0	5536.0
Feed cost per bird, MK	100	83.36	21.23	25.15	132.86
Income per bird, MK	97	109.44	33.47	26.13	194.19
GMOFC per bird. MK	96	25.69	26.62	(48.42)	90.08
Return on feed cost, %	96	34.80	38.10	(42.33)	150.63
Return on bird & feed cost, %	96	24.13	25.90	(29.92)	106.15

n = number of birds; SD = standard deviation; GMOFC = Gross margin over feed cost; MK = Malawi Kwacha (1US$ = MK85.00); Values in brackets are negative.

Table 8: Least square means and SE for gross margin over feed cost and rates of returns by batch and sex of birds

Factor		GMOFC, MK		Return on feed cost, %		Return on bird and feed cost, %	
		Lsmean	SE	Lsmean	SE	Lsmean	SE
Batch	1	30.68	4.09	43.15	5.85	29.73	3.98
	2	24.63	3.98	30.76	5.70	21.59	3.88
Sex	Female	22.67	3.24	31.79	4.63	21.97	3.15
	Male	32.65	5.01	42.11	7.17	29.35	4.88

GMOFC = Gross margin over feed cost; MK = Malawi Kwacha (1US$ = 85.00 MK)

G x E interaction: In general, genetic parameters could be better estimated under these conditions of improved feeding. However, there is need to check if local chickens express some genotype by environment (G x E) interaction, if the results determined under improved feeding could be applicable to local free-ranging environment. In genetic analysis, genetic correlations between 0.9 and 1.0 suggest that two traits are the same (Kerr *et al*., 2001).

Lower correlation coefficients imply small covariance between the two observations. This indicates presence of a stronger interaction (Lin and Togashi, 2002). The dam-hen effect and ranking was expected to be similar in the two management systems and hence show high correlation coefficients. The results obtained showed correlation coefficients ranging from 0.22 - 0.53. Common covariance in these correlations was due to genetic and maternal effects. The low correlation coefficients show possibility of individual G x E interaction being expressed in growth traits for local chickens. This means local chickens are sensitive to environmental changes. Use of parameters determined under improved feeding in this case is only to show potential performance of local chickens under free-ranging environment (Prado - Gonzalez *et al*., 2003).

Economic evaluation of feeding local chickens: Gross margins and rates of returns on feed costs were positive. The observed rates of return are a possible contribution of high costs of feed and poor feed conversion efficiency of these local chickens. This return declined when initial value of birds was included. When all costs, such as labour involved with intensification and treatment are taken into consideration, it would not be economically justifiable to improve feeding of local chickens, as observed by Demeke (2003). Pedersen (2002) found negative gross margins of US$28 for intensively managed local chickens from day old in Zimbabwe. Local chickens are appropriate for the low input scavenging system. Lwesya *et al*. (2004) reported positive response of supplementing local chickens a locally formulated ration on early chick growth rate and return to lay of hens. However, the ration was not economically viable. This poses a challenge to utilize the advantages of the low-input system while at the same time attempt to achieve their genetic potential. On assumption that the low-input system will prevail in rural communities and that currently there is no suitable breed to substitute local chickens, investigations into optimal feeding strategies ranging from supplement feeding to whole feeding are encouraged within the framework of the farming system.

Conclusion: The growth potential of local chickens is not fully exploited under free-range (scavenging) conditions due to inadequate feeds. Feeding management contributes to about 30% of their growth potential. Growth of local chickens can be enhanced through improved management under free-ranging conditions. The option of improved feeding of local chickens under confined conditions is, however, economically not attractive enough to warrant farmers adopting it.

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[1]Local names reported by Gondwe *et al.* (1999).