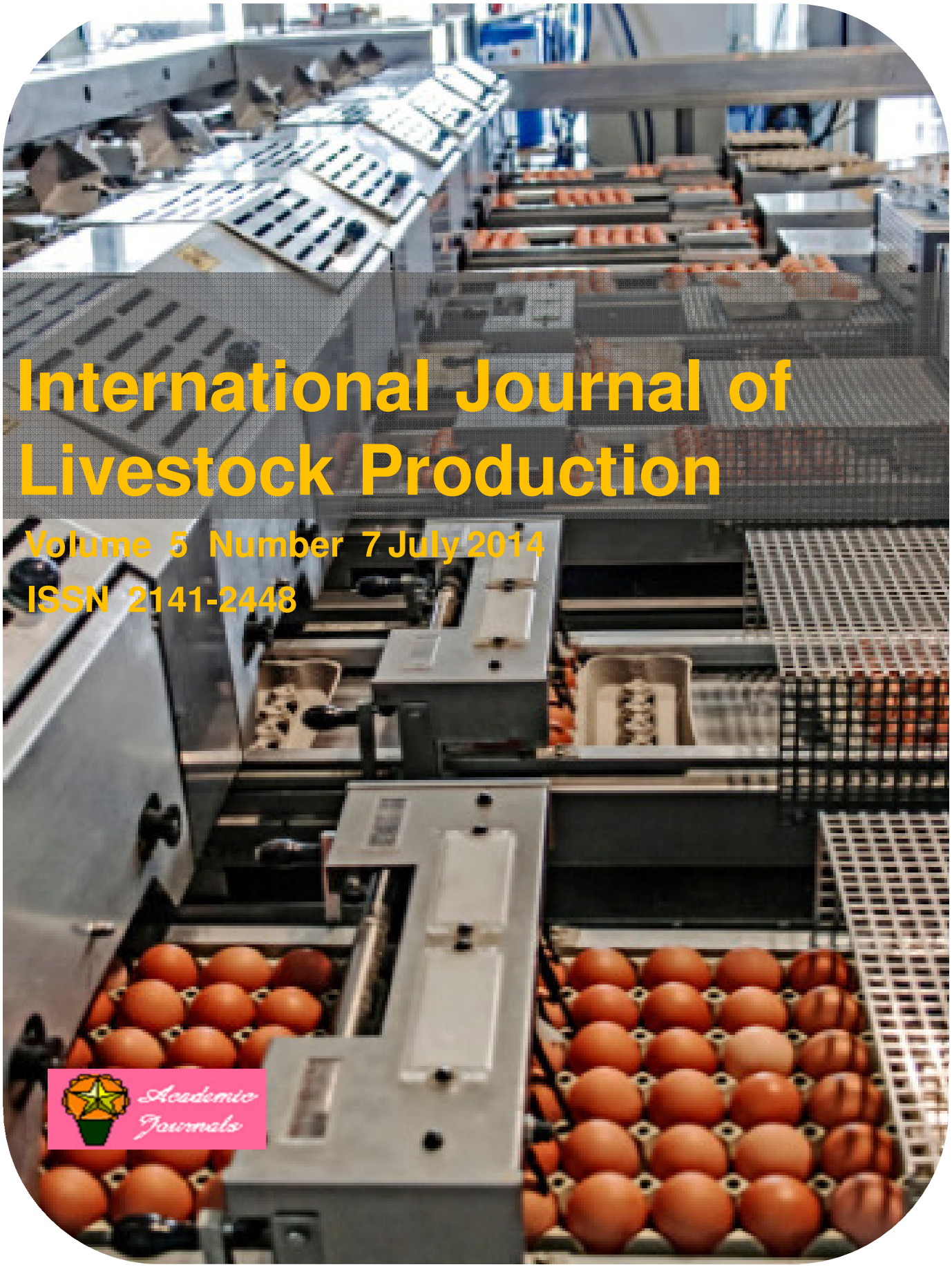

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Full Length Research Paper

Economics of phytase enzyme supplementation in low energy-protein layer chicken diet

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A production trial was carried out utilizing 200 single comb White Leghorn hybrid Athulya layers to study the economics of phytase supplementation at three different levels in low energy-protein diet with reference to the cost of egg production and net profit per egg for a period of 20 weeks. Phytase was supplemented at 0, 500 and 1000 units/kg in low energy, protein and energy-protein layer diets containing available phosphorus of 0.30% from 21 to 40 weeks of age. Significantly (P < 0.01) lower cost of production of an egg and increased net profit were recorded among various phytase supplemented dietary treatments when compared with standard layer and unsupplemented diets fed treatment groups.

Key words: Phytase, layer, economics.

INTRODUCTION

Indian poultry industry has changed from a back yard unit to a giant commercial egg and meat producing farms in the last three decades. Today, India ranks third in commercial egg production and fourth in broiler meat production in the world (USDA/FAS, 2011). The per capita availability of egg increased from 20 in 1950 to 52 in 2012. In 2012, India's egg production is anticipated to reach 61.5 billion eggs, up 68% from 36.6 billion in 2001(USDA/FAS, 2011). According to the Ministry of Food Processing Industries, about 70% of poultry is in the organized sector and 30% is in the unorganized sector. Nearly 60 to 70% of the broiler and layer industries are located in the southern Indian states. Large integrated operations incorporate all aspects of production.

Integration has resulted in lower average costs of production and lower retail prices of egg and poultry meat. One of the major constraints in poultry production is increasing feed cost due to limited availability of cereals and oil cakes. Several attempts have been made to reduce feed cost by incorporation of alternate feed ingredients and grain's by-products. By products like rice bran and wheat bran are available in plenty, however presence of anti-nutritional factors like phytate and non-starch polysaccharides limited their inclusion levels in poultry feed formulation. Most of the cereals and their by-products used in poultry diet have phosphorus in the form of phytate which is not fully utilized by the birds. Phytate also binds with many minerals, protein and other nutrients and make them unavailable to birds. Supplementation of exogenous phytase in poultry feed may hydrolyse the phytate and releases phosphorus and phytate bound nutrients. The present study was aimed to decrease the cost of feed by supplementing the phytase

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Table 1. Allocation of different dietary treatments to experimental birds.

Treatment	Diets	Crude protein (%)	Metabolisable energy (kcal/kg)	Available phosphorus (%)	Phytase units/kg
T1	SLD	18	2600	0.5	0
T2	LED	18	2400	0.3	0
T3	LED	18	2400	0.3	500
T4	LED	18	2400	0.3	1000
T5	LPD	16	2600	0.3	0
T6	LPD	16	2600	0.3	500
T7	LPD	16	2600	0.3	1000
T8	LEPD	16	2400	0.3	0
T9	LEPD	16	2400	0.3	500
T10	LEPD	16	2400	0.3	1000

SLD: Standard layer diet, LED: low energy diet, LPD: low protein diet, and LEPD: low energy-protein diet.

Table 2. Percent ingredient composition of experimental diets.

Ingredient	SLD	LED	LPD	LEPD
Yellow maize	58.00	46.00	58.50	47.00
Soya bean meal	28.35	27.00	22.10	21.00
Wheat bran	2.00	4.10	4.00	5.10
De oiled rice bran	2.00	13.00	5.50	17.00
Dicalcium phosphate	2.00	0.75	0.75	0.75
Shell grit	7.00	8.50	8.50	8.50
Salt	0.20	0.20	0.20	0.20
Merivite	0.015	0.015	0.015	0.015
DL-methionine	0.100	0.100	0.100	0.100
Tefroli	0.100	0.100	0.100	0.100
Meriplex	0.012	0.012	0.012	0.012
Choline chloride	0.120	0.120	0.120	0.120
Ultra TM	0.100	0.100	0.100	0.100
Total	100	100	100	100

SLD: Standard layer diet, LED: low energy diet, LPD: low protein diet, and LEPD: low energy-protein diet.

in low energy, protein and phosphorus layer feed.

MATERIALS AND METHODS

Two hundred single comb White Leghorn hybrid Athulya hybrid layers of 20 weeks old were distributed at random into 10 treatments viz., T1, T2, T3, T4, T5, T6, T7, T8, T9 and T10 with four replications in each treatment and each replicate having five birds. The production trial was carried out from 21 to 40 weeks of age. Four of diets viz., standard layer diet (SLD), low energy (LED), low protein (LPD) and low energy-protein (LEPD) layer diets were used in this study. A standard layer diet (CP-18%, ME-2600 kcal/kg diet, available phosphorus-0.5%) was formulated as per BIS (1992). Experimental diets from T2 to T10 was formulated with two levels of crude protein (18 and 16%), two levels of metabolisable energy (2600 and 2400 ME kcal/kg diet) and three levels of phytase (0,500 and 1000 units/kg) as detailed in Table 1. The available phosphorus level in all treatments except T1 was 0.3%.

The birds were housed in individual cages. Feed and water were supplied *ad libitum* throughout the experimental period of 20 weeks. The inclusion levels of ingredients in different dietary treatments are given in Table 2. During the production period, the daily egg production of individual bird and weekly feed intake of birds were recorded. From this data, number of eggs produced and feed consumed by individual bird was calculated. In order to assess the cost-benefit particulars of supplementation of phytase enzyme in low energy (LED), low protein (LPD) and low energy-protein diets (LEPD) containing 0.3% available phosphorus, the cost of different diets used in the study was calculated based on the actual cost of feed ingredients which prevailed at the time of experiment (August 2011 to January 2012) and are presented in Table 4.

Cost of production of egg was calculated based on the feed consumed to produce an egg and net profit per egg was calculated based on the average price of egg (NECC-Namakkal) which prevailed during the study period and presented in Table 3. The data on cost of production and net profit were subjected to statistical analysis as described by Snedecor and Cochran (1994).

Table 3. Effect of phytase supplementation in low energy-protein diet on cost of production and net profit of an egg in Athulya layer+.

Treatment	Production cost per egg (Rs.)	Net profit per egg (Paise)
	Mean** ± SE	Mean** ± SE
T1	2.01^{cd} ± 0.01	68.80^{ab} ± 1.88
T2	2.05^{d} ± 0.01	64.77^{a} ± 0.70
T3	1.87^{b} ± 0.01	83.45^{c} ± 1.36
T4	1.88^{b} ± 0.03	82.11^{c} ± 2.59
T5	2.01^{cd} ± 0.02	69.46^{ab} ± 2.06
T6	1.86^{b} ± 0.02	83.55^{c} ± 1.71
T7	1.86^{b} ± 0.01	84.25^{cd} ± 1.37
T8	1.97^{c} ± 0.02	72.74^{b} ± 1.94
T9	1.81^{a} ± 0.02	89.09^{d} ± 1.61
T10	1.81^{a} ± 0.02	89.43^{d} ± 1.52
P-value	0.00	0.00

+Means of twenty values with SE. Means within a column with different superscripts differ significantly **($P < 0.01$).

Table 4. Overall economics of phytase supplementation in different experimental diets.

Treatment	Economics of phytase supplementation						
	Particulars						
	Egg produced (no)	Feed intake (kg)	Feed per Egg (g)	Feed cost** (Rs.)	Cost of production (Rs.)	NECC* Price (Rs.)	Profit per egg (Rs.)
T1	2562	317.01	123.74	16.26	2.01	2.7	0.69
T2	2422	326.38	134.76	15.23	2.05	2.7	0.65
T3	2637	322.14	122.16	15.27	1.87	2.7	0.83
T4	2625	322	122.67	15.31	1.88	2.7	0.82
T5	2460	322.5	131.1	15.29	2	2.7	0.7
T6	2647	321.86	121.59	15.33	1.86	2.7	0.84
T7	2644	319.49	120.84	15.37	1.86	2.7	0.84
T8	2344	317.09	135.28	14.59	1.97	2.7	0.73
T9	2604	321.92	123.63	14.63	1.81	2.7	0.89
T10	2630	323.67	123.07	14.67	1.81	2.7	0.89

*Average egg price of National Egg Co-ordination Committee (Namakkal) during the study period. ** Feed including cost of phytase enzyme (Cost of phytase. Rs. 400/kg).

RESULTS AND DISCUSSION

The data on cost of production of an egg varied from 2.05 to 1.81 rupees. The lowest cost of production was noticed in LEPD supplemented with both levels of phytase fed groups (1.81 rupees) and the highest cost of production (2.05 rupees) was noticed in LED fed (T2) control treatment group. The cost of production of an egg for SLD fed birds was similar to that of birds received LED, LPD and LEPD without supplemental phytase. However, the cost of production for LED and LPD supplemented with different levels of phytase were intermediate. Net profit per egg ranged from 64.77 to 89.43 paise. Highest net profit of 89.09 and 89.43 paise per egg were recorded in phytase supplemented LEPD fed groups (T9 and T10) and lowest of 64.77 paise in LED (T2) fed control group. Phytase supplemented diets fed birds showed more net profit per egg produced when compared with negative and positive control diets fed birds.

Significantly ($P < 0.01$) lowest cost of production was noticed in birds received LEPD supplemented with phytase 500 and 1000 units/kg (T9 and T10) when compared with all other treatments. However, the cost of production in LED and LPD supplemented with phytase (500 and 1000 units/kg) fed groups were comparable and was significantly lower than that of SLD fed group and supplemented negative control groups and higher than birds fed LEPD with supplemental phytase. The cost of

production of an egg in (T8) LEPD fed negative control group was significantly lower than that of LED (T2) fed control group and was comparable with SLD (T1-positive control) and LPD fed (T5) control groups.

Significantly ($P < 0.01$) highest net profit per egg was noticed in birds received LEPD supplemented with phytase 500 and 1000 units/kg (T9 and T10) when compared with all other treatments except birds in T7. Net profit per egg of phytase supplemented LED and LPD fed birds was significantly higher than all control groups and lower than phytase added LEPD fed groups except T7. Significantly lowest net profit per egg was observed in LED fed control group (T2) and was comparable with birds fed SLD (T1) and unsupplemented LPD (T5). However, birds fed unsupplemented LEPD showed significantly more profit than birds in T2 and was comparable with birds in T1 and T5.

The present finding is in disagreement with Sukumar (1999) who found that cost of feed per egg was 85.95, 84.87 and 88.08 paise for addition of phytase at 200, 300 and 400 units/kg in low available phosphorus layer diet, respectively. He also noticed a lowest cost of production (84.04 paise) per egg in unsupplemented diet fed groups and cost of an egg in positive control diet fed group was 85.94 paise. Similarly, no significant difference in the net profit per egg was observed by Kannan (2004).

Supplementation of phytase increased net profit per egg due to production of more eggs and reduction in daily feed intake. Exogenous phytase addition in low energy-protein and low available phosphorus layer diet might have increased the availability of phytate bind nutrients which in turn augmented more egg production. Based on the results of this experiment, it can be inferred that the energy, protein and available phosphorus levels can be reduced simultaneously in layer diet with addition of phytase at either 500 or 1000 units/kg. Incorporation of phytase in low energy-protein layer diet showed a scope for inclusion of higher levels of rice and wheat bran in layer diet thereby opening an avenue for lowering of feed cost.

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International Journal of Livestock Production

Full Length Research Paper

Honeybee colony marketing and its implications for queen rearing and beekeeping development in Tigray, Ethiopia

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Colony marketing is an important venture in Werieleke district of Tigray region in Ethiopia. This research was conducted in Nebelet and Maikinetal colony market centres of the district to characterize market actors, colonies, the markets and prices by interviewing 120 market actors. This was run for 6 market days at one week interval (July to September in 2010) by interviewing 5 sellers and 5 purchasers from each market daily. The price of colony in Nebelet was significantly higher than that of Maikinetal ($P < 0.0001$). The highest price was found at the 3rd week of August in Nebelet (925 ± 11.64) and at the 2nd week of August in Maikinetal (596 ± 11.64). Colony marketing had been neglected in the area. Difficulties in determining quality of queen, deserting worker bees, damaging bees by heat and suffocation, comb breakage, lack of awareness on safety, lack of protective are some of the constraints faced. Colonies are flowing from the highlands, which may result in genetic erosion and other problems. Therefore, a law should be established to standardize marketable colonies, conserve bee biodiversity and avoid disease transmission. Beekeepers should be encouraged to multiply their own colonies and rear queens at their specific sites.

Key words: Beekeeping, colony, marketing, queen rearing, price.

INTRODUCTION

The government and NGOs are trying to use beekeeping as a tool for poverty alleviation in Ethiopia through provision of equipments and trainings. This increased promotion of beekeeping is creating an increasing demand for bee colonies. In contrary, the population of domestic colonies has declined from 5.15 million in 2009 (CSA, 2009) to 4.77 million in 2012 (CAS, 2012). Hence, colony marketing is becoming an important business for some beekeepers. It is a common practice in the semi-arid areas of Northern Ethiopia such as Bure district of Amhara region (Yigzaw et al., 2010), Ahferom (Nuru, 2008) and Werieleke (Teweldemedhn and Yayneshet, 2012) districts of Tigray region. This practice is an important source of income for colony sellers, both traders and producers. It is an important source of colony for beekeepers; both for start up, expansion and replacement. Colony marketing in Tigray can be classified into two categories; namely colony marketing at

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Figure 1. Nebelet colony market centre.

colony marketing at central market places. Nebelet and Maikinetal are the two major central colony market places located in Werieleke district. However, little research (Nuru, 2008) has been done so far about this unique practice of colony marketing. Therefore, the objectives of this study were to assess the origin and destination of honeybee colonies, price trends, constraints and opportunities of honeybee colony marketing.

MATERIALS AND METHODS

Description of study areas

The study was conducted in Werieleke district of Tigray (13°45' to 14°10'N latitude and 38°50' to 39°20'E longitude). Two small towns Nebelet and Maikinetal were deliberately selected, as these are the only towns in the district where the tradition of colony marketing exists. These markets are among the major colony marketing centres in the region.

Sampling and data collection

Visits were made to the markets during the weekly market days and this was repeated for six market days (from the 4th week of July to the 1st week of September) throughout the colony marketing season in 2011 at a week interval. Personal observations and semi-structured questionnaires were employed to characterize colony sellers, purchasers, the physical market, the colonies, and price trends within the season and between years (from 1999 to 2010). To get information about the past, elder colony sellers were selected and interviewed. For this reason, market actors were stratified into two as colony sellers and colony purchasers. Afterwards, five colony sellers and five colony purchasers were purposively selected based on information they had from each market centre and each data collection day. Hence, a total of 120 individuals were interviewed using pre-tested semi-structured questionnaires. Colony market day and market place were considered as independent factors.

Data analysis

Descriptive statistics such as means, percentages and frequencies were used to summarize variables such as sex and practices of colony transporting. Colony prices in relation to market day and place were tested for statistical significances using two-way ANOVA at $P < 0.05$.

Statistical significances for nominal and ordinal data were tested using chi-square test in order to characterize colony market actors. Pearson correlation was also calculated for price trends of colonies, honey and hives. All statistical analyses were carried out using JMP5 statistical package.

RESULTS

Poorly equipped markets

According to the respondents from Nebelet, colony selling started since 1980s. At the time of starting, the market was located at farmlands in the Southern vicinity of the town. However, with time, this was translocated to the wastelands in the South-East vicinity of the town. Finally, when that place was allocated for other livestock marketing in the early 2000s, the colony market area was transferred again to Eastern part of the town. This area is rocky, well drained, devoid of plants, nearer to the main entry and exit road in the East ward of the town (Figure 1). Hence, people and animals pass through the edge of this colony market area without any safety precaution.

On the other hand, it became difficult to trace back the time during which colony marketing started in Maikinetal. But one can estimate that it could have at least as equal age as that of Nebelet by analyzing the background of beekeeping practice in the area. This market is located in the periphery of the main entry and exit road in the North-West of the town. It is simply a hilly side devoid of infrastructure except naturally grown scattered *Acacia* trees used as shelters (Figure 2).

Market actors

Market actors in the central colony market places of Werieleke could be classified as colony sellers and purchasers, but labourers and mediators were also involved.

Figure 2. Maikinetal colony market centre.

Table 1. Characteristics of colony sellers in Nebelet and Maikinetal markets.

Parameter	Nebelet (N = 30)	Maikinetal (N = 30)	X^2, P-Value
Sex			
Male	100 (30)	100(30)	
Female	0 (0)	0 (0)	
Average age (years)	45.17 ± 6.86[a]	34.3 ± 5.40[b]	P < 0.0001
One way distance (hours) to the market	4.27 ± 1.22[a]	3.45 ± 0.95[b]	P = 0.0055
Number of years participated in selling bees	16.1 ± 5.01[a]	8 ± 3.25[b]	P < 0.0001
Number of colonies sold			
Colony/day/person	2.47 ± 0.97	2.03 ± 0.93	P = 0.0862
Colony/season/person	4.73 ± 1.62	4.37 ± 1.38	P = 0.436
Proportion of sellers by type			
Producers	86.67(26)	50 (15)	
Hunters	0 (0)	50 (15)	X^2 29.327
Traders	13.33(4)	0 (0)	P < 0.0001

N.B: -Numbers in parenthesis are frequencies; -Means with different superscripts along the rows are significantly different.

Labourers were involved in transporting colonies to and from the market centres by carrying the colonies. These labourers were male, landless youths, young family members or relatives of the colony sellers. Landless youths were paid their daily wages on cash but family members and relatives were not paid.

Colony sellers in both market centres were exclusively males. The sellers in Nebelet were significantly older (P < 0.0001), had longer experience in colony selling and travelled longer distances to reach the market than those who were selling colonies in Maikinetal. The average age was 45.17 ± 6.86 (n = 30) and 34.3 ± 5.40 (n = 30) years for sellers in Nebelet and Maikinetal, respectively. The average one way walking time to reach the market in Nebelet and Maikinetal was 4 h 16 min, and 3 h and 27 min, respectively. The sellers in Nebelet were mainly producers (88.33%) who practice colony multiplication using swarming (in Ganta-Afeshum district) and splitting (in Ahferom and Werieleke districts). The remaining were traders who purchased and collected the colonies from beekeepers' apiaries and sell them at the central market. Sellers in Maikinetal were producers (splitting, swarming) and hunters in equal ratio. Hunters were mainly landless youths from the lowlands. The average number of colonies sold was 2.5 ± 0.97 and 2.0 ± 0.93 per day per person in Nebelet and Maikinetal, respectively (Table 1). Male colony purchasers accounted for 90% in Nebelet and 93% in Maikinetal. Purchasers in Maikinetal were older than in Nebelet (43.1 ± 7.47 vs 48.3 ± 6.42). Higher numbers of colonies were purchased per person per day in Maikinetal than in Nebelet (1.27 ± 0.45 vs 1.53 ± 0.51). About 85 and 90% of the bought colonies in Nebelet and

Table 2. Characteristics of colony purchasers in Nebelet and Maikinetal markets.

Parameter	Market places		P-value
	Nebelet (N = 30)	Maikinetal (N = 30)	
Sex			
Male	90 (27)	93.33 (28)	0.639
Female	10 (3)	6.67(2)	
Average age (year)	43.07 ± 7.47 [b]	48.27 ± 6.42 [a]	0.0054
Colonies purchased/person	1.27 ± 0.45 [b]	1.53 ± 0.51 [a]	0.0366
Type of hive to be used			
Modern	83.33 (25)	90 (27)	0.221
Traditional	16.67(5)	10 (3)	
Supplier of modern hives			
Relief Society of Tigray	83.33 (25)	80 (24)	0.739
Bureau of Agriculture and rural development	16.67(5)	20 (6)	
Training			
Trained	76.67 (23)	73.33(22)	0.766
Not trained	23.33(7)	26.67(8)	
Percentages of purchasers by type			
Start up	30 (9)	36.67 (11)	
Expansion	36.67 (11)	40 (12)	0.678
Replacement	33.33 (10)	23.33 (7)	

-Numbers in parenthesis are frequencies; -Means with different superscripts along the rows are significantly different.

Maikinetal, respectively were aimed to be kept in modern frame hives (Table 2).

Nature of the colonies

Colonies supplied to the markets were nested in traditional hives ranging from conical to cylindrical in shape and made of cow dung. The number and strength of the colonies in the markets varied across the market days in the summer season. The number of colonies in both markets was the lowest in July and reached a peak in the 2nd and 3rd weeks of August in Maikinetal and Nebelet, respectively (Figure 3).

The strength of the colonies was generally increased up to mid of August starting from the beginning of colony marketing season. After this, young colonies with new queen and not well established colonies started to appear in the markets (Figure 4).

Colonies in Nebelet were generally stronger than that of Maikinetal. Moreover, a special practice of worker bee collection was observed in Maikinetal, where beekeepers went to the market with empty hive(s) but caged queen(s). These beekeepers smear their hives with aromatic plants and put their queens inside the hive then hang them on trees in the market (Figure 5). In the evening of the same day, these hives were observed to be filled with as many worker bees as a weak colony at the same market. Such false colonies are meant to be sold by cheating inexperienced purchasers some days later.

In addition to colony selling and worker bee collection, queen bee selling was a common practice in Maikinetal. The price of a queen was 15 Ethiopian Birr[1]. Farmers did not provide feed for their queens while they were caged in the market. The queens stay arrested in cages before they are taken to the market regardless of their fecundity.

Colony transport

Both honeybee colony sellers and purchasers transported their colonies to and from the markets on foot by carrying them on their shoulders. Traditional hives that contain colonies for sale were fixed on top of a forked wooden tool of greater than or equal to the length of the hive (Figure 6). This tool is supposed to assist in holding the hive and minimizing its breakage. This practice was considered essential by colony sellers in Nebelet. However, most purchasers in both markets and sellers in

[1] Birr is an Ethiopian currency. Currently (July 2013), one US $ is equal to 18.58 Birr.

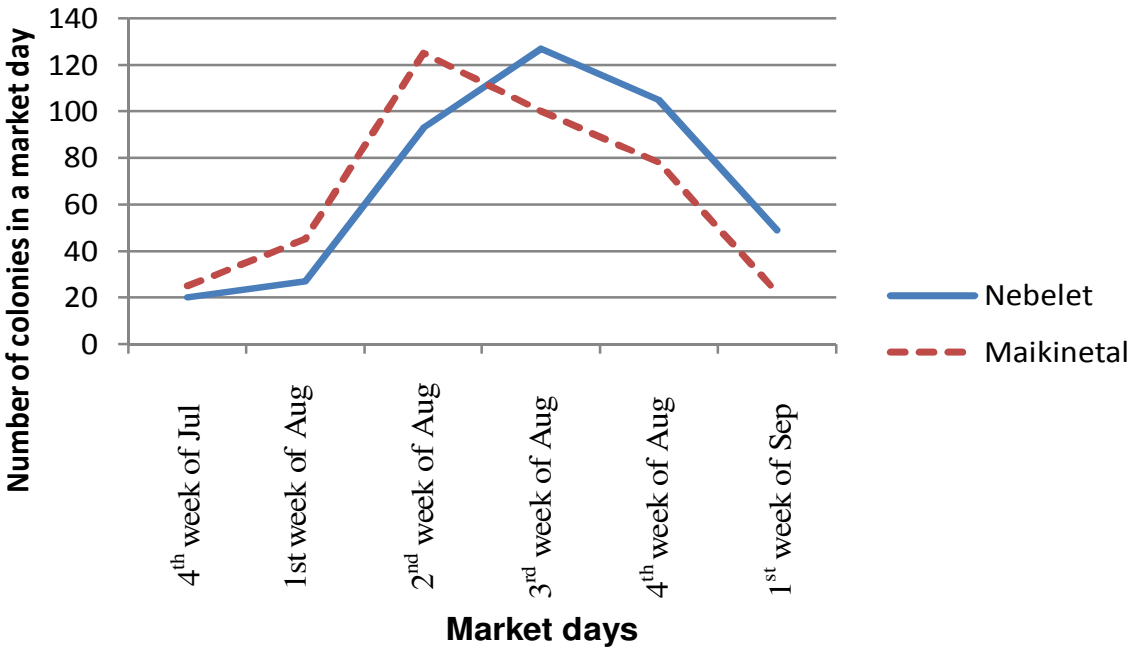

Figure 3. Number of colonies present in Nebelet and Maikinetal.

Figure 4. Varieties of colonies in the colony markets.

Figure 5. Worker bee attraction and queen selling in Maikinetal.

Figure 6. Ways of colony transporting to and from market.

Table 3. Practices used during transporting colony in Nebelet and Maikinetal markets.

Practice	Nebelet		Maikinetal		P-value
	Sellers	Purchasers	Sellers	Purchasers	(place type interaction)
Type of hive holder used					**=0.896**
Forked tool (wooden)	30(100)	5(16.67)	14(46.67)	0(0)	=0.883
Woven/'*Kefer*'	0(0)	25(83.33)	16(53.33)	30(100)	=0.993
Type of hive lid used					
Mesh	18(60)	13(43.33)	15(50)	9(30)	=0.676
Thick cloth/sack	7(23.33)	17(56.67)	9(30)	21(70)	=0.0196
Dung	3(10)	0	4(13.33)	0	=0.999
'*Sefee*'	2(6.67)	0	2(6.67)	0	
Resting of bees for ventilation					=0.999
Rest	23(76.67)	3(10)	8(26.67)	6(20)	= .999
Do not rest	7(23.33)	27(90)	22(73.33)	24(80)	=0.999
Support for combs?					=0.967
Use	25(83.33)	0(0)	0(0)	0(0)	=0.967
Do not use	5(16.67)	30(100)	30(100)	30(100)	=0.967
Caging of queen in the market					
Cage	30(100)		20(66.67)		
Do not cage	0(0)		10(33.33)		

Numbers in parenthesis are percentages.

Maikinetal transported colonies by holding them in a woven basket type of household tool called '*Kefer' (*Figure 6). Sellers in Maikinetal know about the forked tool but they preferred *Kefer* because the hives of their colonies are smaller enough to be placed inside this basket type tool. During transport, hive lid varied from home made dry dung and '*sefee*' to dark/thick cloths and thin/transparent well ventilated meshes.

To avoid heat accumulation inside the hives and damage to the bees, sellers travel early in the morning, and attentively monitor the sound of their bees. When the vibrating sound of bees is increased in an effort to maintain the temperature of the hive, colony sellers go to a shelter, any tree nearby their path, and let the colonies to rest and cool down by opening their cover. They also used a thin/transparent well ventilated meshed cloth as a cover. This was a common practice to those who sell colonies in Nebelet. Colony sellers who travelled longer distances have various mechanisms to avoid or minimize these risks (Table 3).

Figure 7. Comb breakage and prevention technique during colony transport

Figure 8. Knowledgeable beekeeper orienting colony purchasers at Maikinetal.

Breakage of combs was one of the risks in colony transporting whose frequency increased with the strength of colonies. To avoid this, supporting combs with dried cow dung was commonly practiced by colony sellers in Nebelet. However, both sellers and purchasers in Maikinetal did not know how to avoid the risk of comb breakage. Consequently, some of the stronger colonies broke their combs and the bees were damaged (Figure 7).

Colony marketing

Colony marketing system in Werieleke was an open system where price was determined through direct negotiation of purchasers and sellers. The process of pricing was determined by the strength and quality of colonies and queens. Indicative factors used for pricing include queen presence, its age and fertility, and docility of the bees. However, many purchasers did not know how to evaluate colonies and were assisted by knowledgeable people (Figure 8).

The risks that purchasers and sellers faced and the remedies they employed are summarized in Table 4. The major risk the colony sellers faced during selling was loss of some worker bees. Worker bees were deserting by some dazzling colony sellers who were skilful to attract bees from other colonies gathered in the market.

Inter-annual colony price trend

The average price of a bee colony was significantly ($P = 0.0039$) higher in Nebelet than in Maikinetal (771.33 Vs 528.67 birr). Price of bee colonies had been increasing continuously at an average rate of 11.3 and 13.1% per

Table 4. Risks and remedies of purchasers and sellers in Nebelet and Maikinetal markets.

Category	Risk	Remedies
Purchasers	Queenless colony	-Look for presence of brood
		-Look for queen if caged
		-Agreement
	Quality of queen	
	Age	-Bright colour of combs and regularly patterned larva
	Fertility/clipped wing	-Presence of larva
	Aggressive bees	-Observation
Sellers	Loss/deserting/robbing workers bees	-Isolating away from suspected colonies
		-Pushing away suspected colonies
		-Closing bees within their hive

Table 5. Pearson correlation between colony price, honey price and cost of modern hive.

	Colony price in Nebelet	Colony price in Maikinetal	Honey price (modern)	Honey price (traditional)
Colony price in Maikinetal				
R	0.956	1		
P	0.044			
Honey price (modern)				
R	0.976	0.958	1	
P	0.024	0.042		
Honey price (Traditional)				
R	0.996	0.941	0.984	1
P	0.004	0.059	0.016	
Cost of hive				
R	0.778	0.794	0.895	0.814
P	0.222	0.206	0.105	0.186

year over the period of 1999 to 2010 for Nebelet and Maikinetal, respectively (Table 5). The average price per colony was 231 ± 25.14 and 125 ± 20.14 in 1999 and grew to 925 ± 41.43 and 596 ± 35.65 in 2010 for Nebelet and Maikinetal, respectively (Figure 9). A strong positive correlation was found between colony prices in both markets, price of honey of modern and traditional hives in the district, as well as cost of modern hives (Table 5).

Intra-annual colony price trend

The prices of bee colonies significantly fluctuated between the two market places ($P < 0.0001$) as well as among the market days ($P < 0.0001$). In Maikinetal, it slowly increased from the beginning of the marketing season and reached its peak in the second week of August. On the other hand, the price of a colony in Nebelet sharply increased from the beginning of the marketing season and reached its peak in the 3rd week of August (Table 6). After the peaks, it gradually declines in both cases.

DISCUSSION

Nature of markets

The results on the nature of markets indicated that Nebelet and Maikinetal could be among the oldest

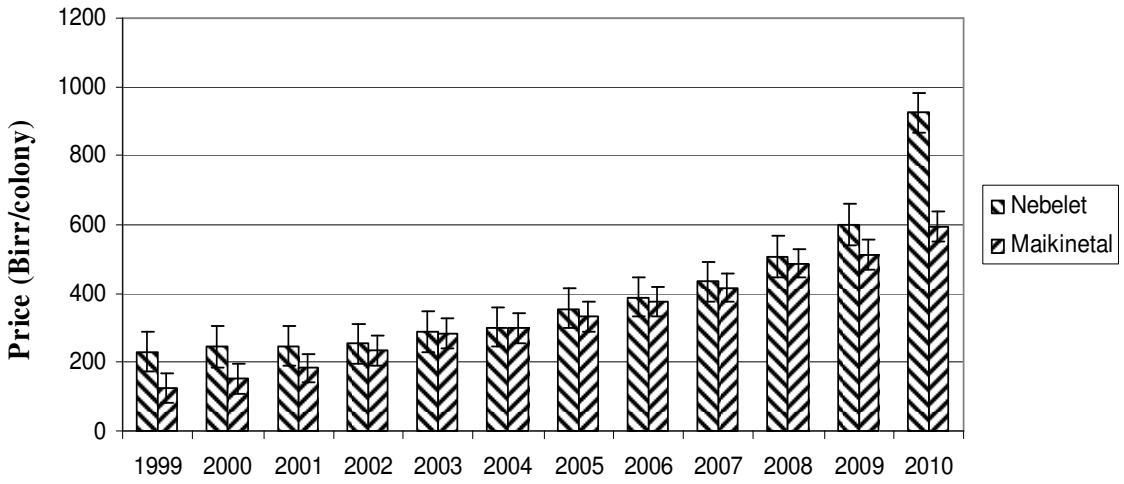

Figure 9. Bee colony price (Birr per colony) trend in Werieleke over 12 years period from 1999 to 2010.

Table 6. Colony price in Nebelet and Maikinetal during 4th week of July to 1st week of Sep (2010).

Week	Market place		P value
	Nebelet	Maikinetal	
4th July	637 ± 1.64^{de}	535 ± 11.64^{gh}	P market place < 0.0001
1st August	687 ± 11.64^{bcd}	565 ± 11.64^{fg}	P marketing week < 0.0001
2nd August	733 ± 11.64^{bc}	596 ± 11.64^{ef}	P interaction < 0.0001
3rd August	925 ± 11.64^{a}	520 ± 11.64^{ghi}	
4th August	883 ± 11.64^{a}	483 ± 11.64^{hi}	
1st September	763 ± 11.64^{b}	473 ± 11.64^{i}	

Means with different superscripts within a row and column differ significantly ($p < 0.05$).

honeybee colony marketing centres in northern Ethiopia. However, they have remained neglected from development. The locations of these colony market centres have changed several times without considering the basic requirements such as suitability and safety precautions. These could be because of less attention of local authorities and experts despite the compulsory apicultural Proclamation 660/2009 of Ethiopia (Federal Negarit Gazeta, 2009). As opposed to that of a nearby colony market called Enticho (Nuru, 2008), taxes were not collected from the sale of colonies in Werieleke, which could have contributed to infrastructural development in the colony market itself.

Nature of market actors

Bee colony multiplication and selling have remained to be a business of men from the highlands. Their clients were male and female headed households in the lowlands and midlands for both traditional and modern hive production systems. This is a reflection of the low potential for honey production (CSA, 2012) of the mountainous areas of Ganta-Afeshum and Ahferom districts which are characterized by less vegetation and climates of windy, cold and comparatively wet with bimodal rainfall patterns. In such areas bees tend to have more broody nature than collecting nectar and storing honey (Verma, 1989). The bees found in the highlands are thought to belong to *Apis mellifera monticola* (Amsalu et al., 2003) although Meixner et al. (2011) have considered the whole honeybees of Ethiopia as a single race. *A. mellifera monticola* is known for its calm behaviour, with good performances in the cool highland areas but fails to adapt in hot lowland areas despite of the availability of bee floras (Ruttner, 1988).

The abundant availability of wild honeybee colonies that are being hunted and brought back to the colony markets by landless youths harbouring in the lowland areas could be a justification for the presence of high rate of absconding among the bees sold to the lowlanders. This agrees with Teweldemedhn and Yayneshet (2012) who have stated that annual colony absconding per household in Werieleke district was the highest in the

lowlands. Furthermore, various ecotypes of bees could be developed to adapt to different agro-ecologies. Bees located in the lowlands of Tigray are classified as *Apis mellifera jementica* (Amsalu et al., 2003). Therefore, the practice of transporting colonies from the highlands to the lowlands and valleys of Werie could have a serious genetic erosion, genetic mix-up and disease transmission. The differences observed in the sources of colonies among the districts could be indications of differences in the tendency of the bee colonies towards swarming and absconding, level of skill of beekeepers and potential of the areas.

Hunting or trapping of colonies is possible in areas having suitable habitat for bees. However, in the mountain areas of Tigray having less vegetation where beekeepers are specialized on colony multiplication, the swarming colonies have less chances to escape and enter someone else bait hive (Nuru, 2008). On the other hand, the existence of significantly younger purchasers who bought fewer bee colonies in Nebelet compared to Maikinetal is an indication of the increasing involvement of landless households in the highlands and midlands in beekeeping.

Beekeeping is an important means for rural livelihood improvement because it does not require more capital, land, labour and technology (Bradbear, 2003) and hence it helps for agricultural wastelands to become productive (Jacobs et al., 2006). Unlike the selling of colonies by predominantly males, women were also purchasing bee colonies in both market centres. This agrees with Yigzaw et al. (2010) who noted that the number of women beekeepers is increasing in recent years as the extension is trying to gender mainstream beekeeping.

Nature of colonies

The variation in the number of bee colonies at the market, their strength throughout the marketing season and the market places clearly reflects the annual colony growth cycle of the areas. Both strength and number of colonies steadily increased up to the second and third weeks of August in Maikinetal and Nebelet, respectively. After this period, small colonies started to appear not only as a result of prime swarming but also after (successive) swarming, which are locally called '*elet'* to mean that weak bee colonies. Hence, the proportion of young colonies increased up to the end of the marketing season in both places. Colonies of the midland market (Nebelet) were generally stronger than that of lowland market (Maikinetal).

At the beginning of the marketing season, colonies were collected by hunting and newly transferred to hives in Maikinetal. The practice of deserting worker bees at Maikinetal market appears to have weakened the colonies. Colony sellers were also frequently quarrelling with the worker bee collectors due to the illegal action of the later. Purchasers also suspected colony sellers of the low quality bees collected in such a manner. Another serious problem investigated in the market was the selling of young queens arrested in traditional cages. The probability of fecundity of such caged queens is very low as the mating flight is generally restricted to a maximum age of 26 days (Cramp, 2008; Sammataro and Avitabile, 2011).

Experiences from Australia show that queen bee marketing is so advanced that high quality queens are sent through postmen in conditioned containers with enough attendants and feed. Unlike to the low level of local beekeepers' and experts' understanding on the biology of bees in Tigray, queen purchasers in developed countries are informed about the age of queens to be taken out of their nucleus hives (Doug, 2009). Beekeepers' and experts' knowledge and skill of bee biology should be considered as the basis for success on beekeeping. Because of this gap, unoccupied modern frame hives as high as 66% were reported in Bure district where colony marketing is recently emerging using hunting as its sole source (Yigzaw et al., 2010). These are implications for introducing appropriate queen rearing techniques in Ethiopia based on knowledge of bee biology.

Practices of colony transport

Underdeveloped transport infrastructure in association with rugged topography restricted the honeybee colony sellers and purchasers to travel on foot for transporting bee colonies to and from the markets. However, their long tradition of colony marketing seems to be enabling them to transport bee colonies safely. The efforts of the beekeepers in avoiding heat accumulation, suffocation and damage are remarkable. This practice is in line with the recommendations of Krell (1996). However, the lowlanders who were selling and purchasing colonies in Maikinetal were comparatively less aware of such requirements, which could be related to their short experience in bee colony marketing. This is because most of them are youths who trap and hunt colonies as a means of getting income without having enough experience in beekeeping and colony transporting.

Practices of colony marketing

In a marketing system where there is no standard for the bees and pricing is highly compromised, the colony purchasers are liable to many risks with regard to the quality of the colonies and queens. This was aggravated by their lack of skill on beekeeping as most of them were beginners. Hence, they were left with the options of hiring a skilled person or buying from known sellers with some kind of guarantee. This is an indication of policy and

extension gaps with respect to beekeeping and colony marketing. The extension office has tried nothing to help such farmers. Deserting worker bees to sell them as if a colony, bringing queenless colonies, and selling unfertilized queens were among the major problems observed due to poor technical backup and loose regulation.

Conflicts were arising because of the collection of worker bees by deserting from their colonies in the market. Such individuals came to the market with weak colonies and/or queen alone. They attract bees from the market using different aromatic plants such as citrus fruits and spices. The fate of such colonies might be absconding shortly after their arrival to their destination since a colony of old workers without a queen and larvae, and a colony with unfertilized queen have no chance of producing bees for the next generations. This risk was more prevalent in Maikinetal than Nebelet, which agrees with an earlier report (Teweldemedhn and Yayneshet, 2012). To avoid the risk, colony sellers attentively watch at the situations around them and immediately react whenever a suspected colony is observed. Either they force the dazzling person to go away with his bees or they close their bees. However, it was difficult to control the situation and beekeepers were complaining for a gap in law that deals with such trespassing.

Inter-annual colony price trend

The fast growth in the inter-annual price of a colony could be associated with the introduction of modern frame hives, increasing price of honey and over all decline in the purchasing power of the Ethiopian currency (Birr). A growing beekeeping industry usually creates a demand for bee colonies (Krell, 1996). Prices of colonies significantly increased in other regions too. This was due to shortage of colonies as a result of degradation, agricultural intensification and poisoning by chemicals, increased demand due to introduction of large number of hives, deprivation of natural multiplication due to introduction of modern hives and lack of skill of colony multiplication (Yigzaw et al., 2010). The strong positive correlations among colony prices in both market centres, price of honey of modern and traditional hives, as well as cost of modern hives supports the above argument.

As long as the commercialization of beekeeping increases through provision of modern beehives while beekeepers are not trained how to produce their own bee colonies, the price of colonies will continuously increase. This in turn is a reflection of the quality-supply-demand for the colonies as clearly seen in the markets. The price of colonies was generally higher in Nebelet than in Maikinetal because the colonies in Maikinetal were heterogeneous ranging from very weak, less established, hunted colony to well established. On the other hand, the demand for colonies was higher in Nebelet than that of Maikinetal. This was because new beekeepers around Nebelet were using the market as their sole source of colonies in contrast to that of new beekeepers around Maikinetal who used hunting.

Intra-annual colony price trend

Similar to the inter-annual patterns, the intra-annual and spatial patterns in price of colonies were fluctuating according to the quality-demand-supply of colonies. That is colonies at the beginning of marketing season were generally weak and they continued to be stronger through time until a new pattern came. Similarly, the supply of colonies at the beginning of marketing season was limited because the time for colony multiplication is later in the season. On the other hand, purchasers of colonies were not confident enough to buy colonies at the beginning of the season while the fate of the weak colonies and the rainfall pattern were difficult to predict. However, purchasers were eager to buy colonies as early as bees and rainfall are predictable. Their aims were to have well established productive colonies before the summer is ended up.

The price of colonies reached its peak earlier in Maikinetal than Nebelet due to the agro-ecological differences between them. Since the lowland areas were characterized by vegetations that bloom quickly after the start of the rainfall, the strength of bee colonies and the demand of beekeepers to purchase colonies grow faster.

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Conflict of interests

The authors have not declared any conflict of interests.

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Full Length Research Paper

Analysis of the determinants of the sustainability of cattle marketing systems in Zambezi Region of north-eastern communal area of Namibia

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This article aims to contribute to a better understanding of variables that influence the motivation behind the preferred choice of cattle marketing channels in north eastern communal area of Namibia. The data required for the study were collected through a small-scale survey, key informants in-depth interviews and review of secondary data were analysed using Multinomial Logistical Regression. The results showed that the majority (62%) of small scale cattle farmers preferred to trade through informal marketing channel (comprising open market, private sales and butcheries). The abattoir was the single most preferred channel for 38% and the only available formal market. Four factors are identified motivating cattle farmers to choose this marketing channel namely, the gender of the household head, marketing information received, education and number of livestock sold. The results also suggest that formal marketing is relatively relevant to farmers with large cattle numbers and meet the required standards from abattoirs. The study recommended that in order to increase the number of cattle marketed through the formal channels, there is need to improve overall herd size, as well as setting attractive prices coupled with reduced delays in making payments to the farmers for their livestock sold.

Key words: Formal market, informal market, factors, sales, agriculture, livestock.

INTRODUCTION

In many rural communities, cattle rearing and marketing makes an important contribution to family food supplies and provides critical support to agricultural production. Cattle farming is very important to farmers living in rural areas as it provides milk, meat, hides, horns and income to meet family financial needs such as school fees and other household expenses as well as source employment, collateral and insurance against natural calamities, dung for manure and draught power for cultivation of crops and transport of goods (Musemwa et al., 2008). In rural communities livestock farming is perceived as a symbol of wealth, social status, prestige and a safeguard against crop failure especially during drought or flood seasons. Socio-cultural functions of cattle include the use of cattle as bride price and to settle disputes (as fine) in communal areas (Chimonyo et al., 1999). Cattle are also reserved for special ceremonial gatherings such as weddings, funerals and circumcision (Musemwa et al., 2008). More importantly, indigenous cattle are valuable reservoirs of genes for adaptive and

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economic traits, providing diversified genetic pool, which can help in meeting future challenges resulting from changes in production sources and market requirements (Chimonyo et al., 1999).

Moreover, livestock production especially cattle in communal areas in sub-Saharan Africa is constrained by a variety of factors that lead to low productivity. These include shortages of good quality livestock feed during the dry season, high incidences of diseases and mortality rates, unavailability of or access to healthy water (Mutibvu et al., 2012). Water points are sometimes limited and large numbers of animals use the same points leading to high chances of spreading diseases and land degradation. Other factors include the failure of government services to provide veterinary health services, poor housing, low soil fertility for forage production and weak market chains for livestock and livestock products (Mutibvu et al., 2012). Kapimbi and Teweldemedhin (2012) also added extreme climate conditions such as floods and droughts and manmade factors such as livestock theft and careless starting of fires.

In Namibia cattle, goats, sheep and pigs contribute 76% of the national agricultural output value, whereas 6% comes from communal areas (NDP4, 2012). According to the 2012 livestock census, Namibia has a total of 2.9 million cattle of which 1.4 million are found in the Northern Communal Areas (NCAs) of which Zambezi region has 136 221and the rest are south of the Veterinary Cordon Fence (VCF) which constitutes the World Organization for Animal Health recognized Foot and Mouth Disease (FMD) Free zone status (Meat Board of Namibia, 2012). Cattle farming in Namibia is the main agricultural production sector in the country of which the value of production is annually estimated at N$900 million, and of which approximately N$400 million is being contributed by live weaner exports to South Africa (Meat Board of Namibia, 2007).

Currently the VCF split Namibia into distinct animal disease control zones. The VCF divides the north central which is FMD protected and the north east which is FMD prone area from the south which is FMD free zone. Meat and livestock cannot pass freely over the VCF into southern FMD free zone which makes the marketing of cattle very difficult (Düvel and Stephanus, 2000). Approximately, 60% of livestock in Namibia remain north of the VCF as a result they are excluded from the lucrative world markets such as that of European Union (EU) (NDP4, 2012).

Moreover, marketing should play a vitally important role in the process of transforming small scale farmers into commercial producers (Coetzee et al., 2005). Yet it is important to note that the marketing channels available to small-scale producers are still limited due to their relative small size (Schmitz et al., 2003). According to Kruger and Lammerts-Imbuwa (2008) cattle producers in the NCAs have an option to sell their cattle to the formal (mainly to the government-owned parastatal MeatCo) or informal market (indigenous market) (De Bruyn et al., 2001). Formal marketing channel includes selling at abattoirs and auctions while informal marketing includes selling to small butcheries, fellow farmers, individual speculators and bush marketing. The decision to sell in the informal market, formal market or combinations depends on the transaction costs incurred during the sale of animals (De Bruyn et al., 2001). Notably, the participation in the marketing system has more to do with the number of cattle owned (Hangara et al., 2012; Enkono et al., 2013). According to Nkosi and Kirsten (1993) the apparent reason for selling cattle amongst farmers in developing countries is emergency sales. This is so because cattle sales emerge from economic circumstances that compel owners to sell in order to obtain sufficient money to purchase pressing needs (Nkosi and Kirsten, 1993). There is a need, however, to promote informal market participation in order to increasingly recognize the efforts of bringing about agricultural change in Namibia since traditionally, farmers sell cattle when they need money (Shiimi et al., 2010).

For cattle producers in the NCAs to qualify to market their cattle to formal market e.g. MeatCo, it is a prerequisite that their cattle have to be kept in quarantine camps for diseases (mainly FMD and Contagious bovine pleuropneumonia (CBPP) or lung sickness) inspection for a period of 21 days before slaughtering and their meat products enters the south of VCF in Namibia or the Republic of South African market. However, access to formal markets is limited by a number of factors, chiefly of which are the distance from the market and inadequate marketing infrastructures. For example only two MeatCo abattoirs, at least 1000 km apart exist in NCAs which are certified for beef export to mainly South Africa namely Oshakati in north central and Katima Mulilo in north east of the country (Kruger and Lammerts-Imbuwa, 2008).

Cattle quarantine is associated with high transaction costs in the formal markets because cattle often lose condition (that is, weight and grading in the quarantine camps due to insufficient feed causing low prices (Kirsten, 2002) as well as due to long distances producers have to transport animals to quarantine camps (Kapimbi and Teweldemedhin, 2012). Makhura (2001) argues that poor condition of livestock also results in farmers getting low farm gate prices especially during dry conditions (drought years). The age of animals is also important as farmers tend to sell older animals and equally contributes to poor prices (Nkosi and Kirsten, 1993). Cattle farmers prefer selling older cattle because the younger ones (females) are used for breeding purposes. Due to lower livestock prices in rural areas farmers more often, refuse to sell their cattle to formal markets. The biggest challenge to livestock farmers in the communal area is lack of capacity building in satisfying the buyers' quality expectations and understanding the marketing system in general (Kapimbi and Teweldemedhin,

2012). In Namibia the lack of disease-free status in the NCAs and limited market access also restricts farmers to informal marketing of cattle and their products (MCA Namibia, 2013). Animal health issues are barriers to trade in livestock and their products, whilst specific diseases decrease production and increase morbidity and mortality (Düvel and Stephanus, 2000). The main diseases include anthrax, FMD, black-leg and CBPP. Furthermore, farmers often have inadequate or no insurance coverage on livestock. Additionally, as earlier stated meat and livestock cannot pass freely through the VCF into the southern FMD free zone of Namibia. As a result this complicates the domestic marketing of livestock (cattle) from the NCAs. The estimated average off-take rate in the NCAs is only 7%, compared to 25% in the regions south of the VCF (MCA Namibia, 2013).

The importance of looking for ways to successfully contribute to insights in livestock production and marketing has been covered by several studies in NCAs of Namibia (Düvel and Stephanus, 2000; De Bruyn et al., 2001; Teweldemedhin and Conroy, 2010; Shiimi et al., 2010; Kapimbi and Teweldemedhin, 2012; Enkono et al., 2013). The objective of this study was to contribute to a better understanding of variables that influence the preferred choice of cattle marketing channels in north eastern communal area of Namibia. Thus, the paper will suggest sustainable cattle marketing strategies that would help to improve a supportive institutional environment that ensure agricultural development and economic performance of farmers in communal areas.

MATERIALS AND METHODS

Description of study area

The study was conducted in two villages of Bukalo and Ngoma in Katima Mulilo Rural Constituency of Zambezi region. The Katima Mulilo Rural Constituency surrounds the administrative town, Katima Mulilo in Zambezi region. The constituency has an estimated population of around 16200 people and covers an area of 1952 km^2 (NSA, 2012). The natural environment is mainly dominated by wetlands, woodlands and wildlife. The average annual rainfall in this region is between 600 and 800 mm. Droughts and floods are common in the region. The main farming activities include fishing, cultivation of crops, livestock production (mainly cattle, goats and chicken) and harvesting of indigenous plant products that is, fruits. The region is also dominated by high incidence of cattle diseases such as FMD and CBPP.

Data collection

The data required for the study were collected through a small scale survey, key informants in-depth interviews and review of secondary data. A structured questionnaire consisting both open and closed types of questions to generate detailed information on factors that could influence farmers cattle marketing choices was used. The survey questionnaire was designed to cover the following topics with respect to the study objective: household characteristics, number of cattle owned, farming experience and cattle marketing opportunities and constraints in the interview. A total of 50 farming households who are small scale cattle farmers (owners) were interviewed using a purposive sampling "snowballing" method. The snowballing method identifies cases of interest from people who know people that are information-rich, that is, good examples for study and good interview subjects (Patton, 1990, cited by Milagrosa, 2007). Although the purposive sampling method has some disadvantages such as being highly prone to researcher bias and the sample may not represent the entire population, this method was deemed appropriate given the lack of a farmer database system for the study units.

In addition to the questionnaires, secondary sources of data both published and unpublished information were reviewed. These desk review sources included scientific journal articles, books, newspapers articles and reports. In order to augment the survey data and secondary data, discussions were held with key informants (experts) to get more insight into the study area and to understand previous conducted research and development works. This list included traditional leaders, extension officials, marketing agencies, cattle buyers and researchers.

Data analysis

The quantitative data collected by the structured questionnaire survey were systematically coded and analysed using descriptive statistics of the International Business Machines (IBM) Statistical Package for Social Sciences (SPSS) version 21.0 for windows (2013). As earlier stated the qualitative data generated by the discussions with key informants (experts) were used to substantiate and augment the results from the survey data. The study used the Multinomial Logistical Regression (MLR) to determine the factors that are likely to influence the choice of farmers on whether to use formal or informal livestock marketing channels. MLR can create a profile of factors likely to influence the choice of a particular market. The model was specified as:

$$f(k,i) = \beta_{0,k} + \beta_{0,k}X_{1,i} + \cdots + \beta_{m,k}X_{m,i} \quad (1)$$

MLR uses linear predictor function to predict probability that observation i has outcome k, where $\beta_{m,k}$ is a regression coefficient associated with the m^{th} explanatory variable and the k^{th} outcome. The general empirical model is specified as follows:

$$\ln \frac{Pr}{Pr}\left(\frac{Y_i=K-1}{Y_i=K}\right) = \beta_{k-1}.X_i \quad (2)$$

There are four possible dependent outcomes namely, open market, abattoir, private sales and butcheries. The abattoir is chosen as the pivot outcome K, while open market, private sales and butcheries (K-1) are the outcomes regressed against the pivot outcome. B_{k-1} are the regression coefficients for the possible outcomes and X_i are the independent explanatory variables.

Thus three empirical independent binary regressions can be derived as:

$$\ln \frac{Pr}{Pr}\left(\frac{Y_i=1}{Y_i=K}\right) = \beta_1.X_i \quad (3)$$

$$\ln \frac{Pr}{Pr}\left(\frac{Y_i=2}{Y_i=K}\right) = \beta_2.X_i \quad (4)$$

$$\ln \frac{Pr}{Pr}\left(\frac{Y_i=3}{Y_i=K}\right) = \beta_3 . X_i \quad (5)$$

Where $\ln \frac{Pr}{Pr}\left(\frac{Y_i=1}{Y_i=K}\right)$ is the logarithm of probability of choosing the type of marketing channel, either Y=1 (open market), or Y=2 (butcheries) or Y=3 (private sales). β_{1-3} are the regression coefficients for the Y respectively. X_i represent the explanatory variables, HHG is the gender of household head, EDU is level of education, MINFO is type of marketing information given, LFO is livestock farmers organisation membership, PSDM is method used to set price during marketing while NCS is the number of cattle sold, age of head of household, source of income and employment status of head of household. Table 1 shows the explanatory variables descriptions and hypothesised effect in the model.

RESULTS

Table 2 indicates that more farmers (62%) use informal marketing channels than formal cattle marketing channels (38%). However, the most single used channel is the abattoirs (38%) to market cattle compared to open market (12%), butcheries (22%) and private sales (28%). There are more options for informal marketing (open market, butcheries and private sales) compared to formal marketing channels (abattoir). The majority of farmers obtained secondary education (58%). The results further reveal that of the farmers that sell to the formal market, 76% sell more than 10 cattle while 92% of farmers that sell to informal markets, sell 5 or less cattle per year. The results further indicate that most farmers negotiate the selling prices (64%) regardless of choice of marketing channels. The regression analysis (Table 3) indicates that the explanatory variables that are significant at 10, 5 and 1% in the model account for 99% of the total variation.

DISCUSSION

The model successfully predicted 98% of the observations, with number of cattle highly significant and increasing the likelihood of farmers selling their livestock to the formal market. The model indicated a low log likelihood which is acceptable, with a significant chi-square (X^2) ($p<0.05$). The logit results from the model for the choice of marketing channel are discussed below.

Open market relative to Abattoir

The log odds for open market relative to abattoir was 1.085 and positive indicating increase in preference of the open market relative to abattoir. With reference to being a member of a livestock organisation, increasing educational level, household head gender being male, cattle sales, and marketing information the logit would be expected to increase while holding all other variables constant. Thus preference for abattoir would be expected to increase. Price setting, age of household head, and income source from livestock whose logit are negative would be expected to decrease the preference for open market relative to abattoir when other variables are held constant. However, education and gender of household head have the most significant log odds ratio to increase probability for preference for abattoir compared to open market.

Butchery relative to abattoir

The coefficient is negative and decreases the likelihood for preference of butchery relative to abattoir. Education, and more than 6 but less than 10 cattle, have positive log odds ratios greater than 1 and are expected to increase probability of preference for abattoir relative to sell to butcheries when all other variables are held constant. However, source of income and price setting method had negative log odds ratios of less than 1 and are likely to decrease preference for butchery relative to abattoir.

Private sales relative to abattoir

The logit of preferring private sales relative to abattoir is positive thus it would be expected that it would increase the likelihood of preferring abattoir over private sales. Education log odds ratio is greater than 1 and would be expected to increase the likelihood for preference of abattoir relative to private sales. When a farmer is a member of a livestock organisation as well as increase, in numbers of cattle, the likelihood to use abattoirs increases as well when other variable are held constant. However, method of price setting, source of income and whether one receives market information, have log odds that are less than one which would likely decrease the probability of preference for using abattoirs.

These results have possible policy implications especially in terms of informing policy makers and decision makers on what factors they should focus on to improve access of formal markets. As much as most people in the study area prefer the formal market, those with higher numbers of cattle were shown in the model to increase probability to use abattoir. Therefore, it would help policy makers to come up with strategies that would increase livestock numbers and abattoirs would likely be the market of choice. A possible explanation of these results is that since most farmers' sales are due to emergency cash needs and also due to the fact that they do not have large numbers of livestock, they would probably be forced by circumstances to sale to informal markets. However, those who receive market information, and are educated are likely to come together and sell

Table 1. Descriptive statistics and expected hypothesised effect.

Variable	Mean	Sign	Hypothesised effect
Type of marketing channel (dependent)	1.61	n/a	
Household head gender	1.186	+/-	It is hypothesized that based on traditional norms males own the livestock thus make the decisions on whether to sale or not and which channel to use since they provide for the families
Education level	1.814	+/-	It is hypothesised that the higher the education one receives the better understanding and rational decision making in terms of choices and are as such expected to use more formal channels as they actively seek information
Given market Information	7.093	+	When market information is given, farmers make decisions on based on the information given, if it is favourable they would act on it
Livestock farmers organisation membership	0.047	+	Farmers organisations assist farmers in marketing and thus would be able to access information and markets that would otherwise not be available to them
Number of cattle sold	1.93	+	The more the livestock one has the more likely one is to sell to formal markets
Method of price setting during marketing	1.744	+/-	Farmers are likely to sell their livestock through the markets where they can negotiate the price
Age of head of Household		+	The age of the head of household is expected to influence the decision positively as the older the farmer the more likely he is to have a lot of cattle and experience of the markets and more likely to use formal marketing channels
Employment status		+/-	Employment status is expected to influence choice of market as unemployed are likely to need cash incomes to cover emergency requirements and employed would likely use the formal markets as they have other sources of income
Source of income		+/-	The ones who have other sources of income are likely to choose a market that gives best price that is a market where they can negotiate

their livestock as a collective to the formal markets even when they have fewer cattle.

CONCLUSIONS AND RECOMMENDATIONS

Livestock contributes in different ways to the livelihood of the Namibian people ranging from cash income to meet family financial needs such as school fees, provision of draught power for cultivation of crops and transport of goods, the consumption of animal products as well as source of employment, collateral and insurance against natural calamities and dung for manure. In rural communities livestock farming especially cattle are perceived as a symbol of wealth, social status, prestige include the use of cattle as bride price and to settle disputes (as fine) and also reserved for special ceremonial gatherings such as weddings, funerals and circumcision.

Moreover transforming small scale farmers into commercial cattle producers in northern communal areas of Namibia has not achieved its full potential due to various factors including shortages of good quality livestock feed during the dry season, high incidences of diseases and mortality rates, unavailability of or access to healthy water as well as long distance travelled to the market, poor infrastructures, in adequate institutional support, insufficient training and markets information and high transaction costs and so on. Cattle producers in the NCAs have an option to sell their cattle to the formal (mainly to the government-owned parastatal (MeatCo) or informal market (indigenous market). In order to develop small scale cattle industry the issues that exist need to be jointly addressed by all stakeholders such as government, farmers, producer organisations and private sector alike.

The findings of this study indicated that the majority (62%) of small scale cattle farmers preferred to trade

Table 2. Summary of descriptive variables and choice of marketing channel.

Variable	Type of market		Total
	Formal	Informal	
Gender			
Male	15(30)	24(48)	39(78)
Female	4(8)	7(14)	11(22)
Total	19(38)	31(62)	50 (100)
Education			
None	1(2)	2(4)	3(6)
Primary	3(6)	7(14)	10(20)
Secondary	10(20)	19(38)	29(58)
Tertiary	5(10)	3(6)	8(16)
Total	19 (38)	31(62)	50(100)
Number of cattle sold			
Grouped 1 to 5	2(4)	24(48)	26(52)
Grouped 6 to 10	3(6)	1(2)	4(8)
More than 10	14(28)	6(12)	20(40)
Total	19(38)	31(62)	50(100)
Price setting			
Negotiation	12(24)	20(40)	32(64)
Market driven	3(6)	7(14)	10(20)
Decide by buyers	1(2)	0(0)	1(2)
Decide by sellers	3(6)	4(8)	7(14)
Total	19(38)	31(62)	50(100)
Marketing channel			
Abattoir	19(38)		19(38)
Open market		6(12)	6(12)
Butcheries		11(22)	11(22)
Private sales		14(28)	14(28)
Total	19(38)	31(62)	50(100)

Numbers in brackets indicate percentages.

Table 3. Multinomial Regression estimates of explanatory variables for market choice of open market, butcheries and private sales (informal market) with reference to abattoirs (formal market).

Marketing channel used to market livestock[a]		Coefficient	Std. Error	Odds ratio
Open market	Intercept	1.085	45.869	
	[organisation = not a member of organization]***	123.198	34.287	3.19E+53
	[priceset = negotiation]***	-83.223	31.447	1.00E-13
	[priceset = market drivers]***	-79.695	30.798	1.00E-13
	[priceset = dictated by the buyer]**	-73.173	35.855	1.00E-13
	[income = livestock]**	-19.183	9.201	4.67E-09
	[income = pension and remittance]**	63.072	30.145	2.47E+27
	[income = crop, livestock and remittance]**	-34.606	13.41	1.01E-13
	[education = no education]***	28.978	6.127	3.85E+12
	[education = primary school]***	15.989	5.631	8786679.876
	[education = secondary]***	11.129	1.972	68111.37
	[HHgender = female]*	7.805	4.282	2453.428
	[Age = 40-49]*	-58.076	35.353	1.00E-13

Table 3. Contd.

	[employment = part-time farmer]**	-94.256	37.244	1.00E-13
	[grouped cattle sales = 1-5]***	27.947	4.364	1.37E+12
	[market infor = no]***	10.613	3.352	40649.546
	Intercept	-30.178	47.255	
	[priceset = dictated by the buyer]*	-66.254	37.432	1.00E-13
	[income = livestock]*	-30.104	17.556	1.84E-13
Butcheries	[income = remittance]***	-56.096	21.643	1.00E-13
	[income = crop, livestock & remittance]***	-70.403	21.594	1.00E-13
	[education = primary]***	18.036	6.454	68044113.65
	[grouped cattle sales = 1-5]***	9.447	2.66	12669.059
	[grouped cattle sales = 6-10]*	-33.778	19.184	1.02E-13
	Intercept***	-107.403	34.49	
	[organization = no]***	73.734	11.413	1.05E+32
	[priceset = market drivers]***	-43.452	15.294	1.00E-13
	[income = salary and remittance]*	-21.95	11.943	2.93E-10
	[income = pension and remittance***	-23.6	8.008	5.64E-11
Private sales	[income = crop, livestock and remittance]*	-38.723	20.969	1.00E-13
	[education = no]***	32.898	6.544	1.94E+14
	[education = primary]***	26.391	2.026	2.89E+11
	[education = secondary]***	24.742	1.366	55624065202
	[grouped cattle sales = 1-5]***	33.692	2.595	4.29E+14
	[market infor = no]	-13.02	3.337	2.22E-06
	Log likelihood = 1.622			
	X^2 (df = 87) = 127.347***			
	Pseudo R^2 = 0.994			

*,**,*** Significant at 10, 5 and 1%.

through informal marketing channel compared to 38% who prefer the formal market. Four factors are identified motivating cattle farmers to choose this marketing channel namely, the gender of the household head, marketing information received, education and number of livestock sold. The results suggest that formal marketing is also relatively relevant to farmers with large cattle numbers and meet the required standards from abattoirs. The study recommended that in order to increase the number of cattle marketed through the formal channels, there is need to improve overall herd size, as well as setting attractive prices coupled with reduced delays in making payments to the farmers for their livestock sold. Through government extension officers, farmers should be supported with transport, training and market (prices) information on marketing of their cattle. There is also need to improve marketing infrastructures in the study areas.

Conflict of interests

The authors have not declared any conflict of interests.

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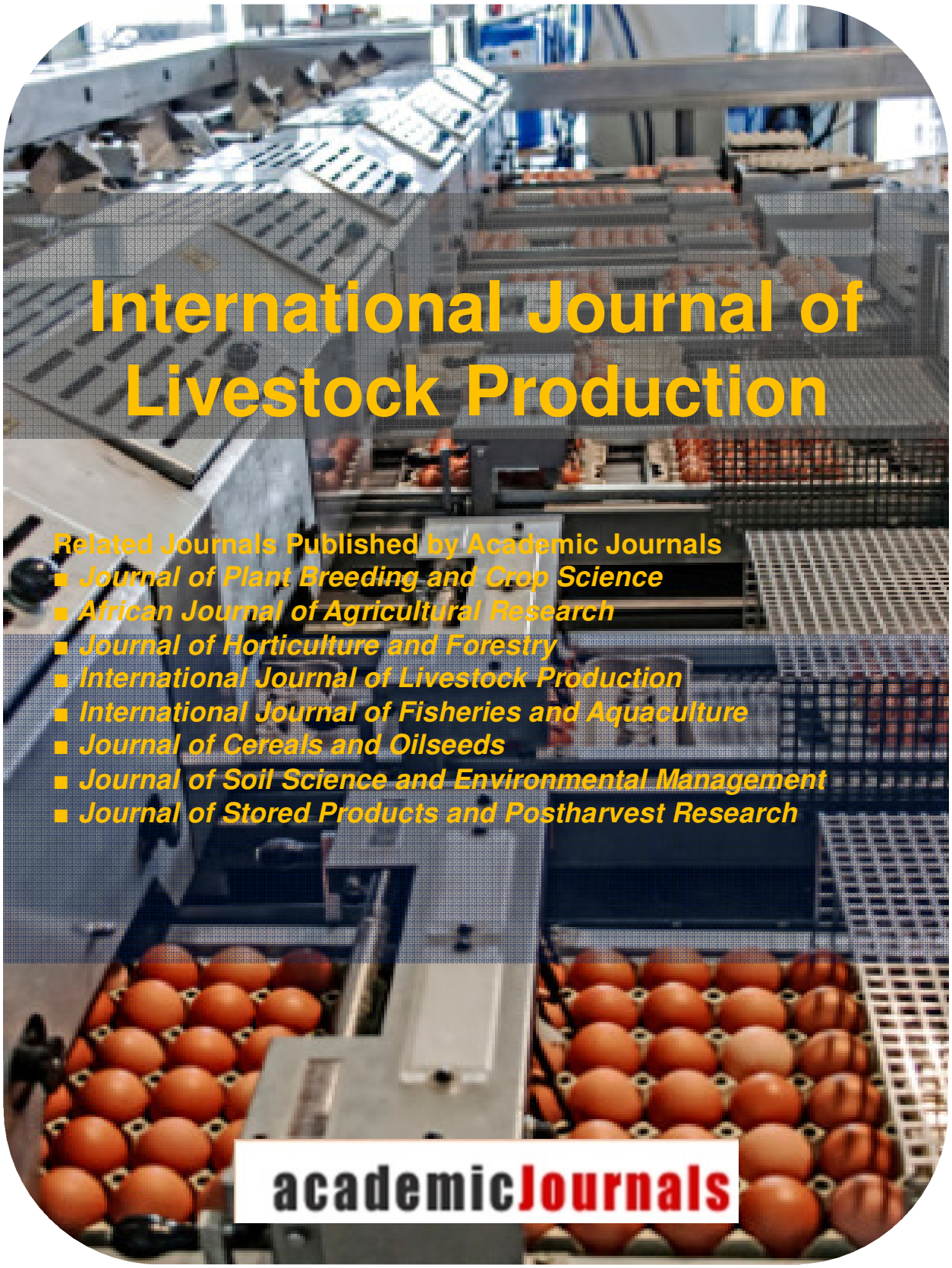

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