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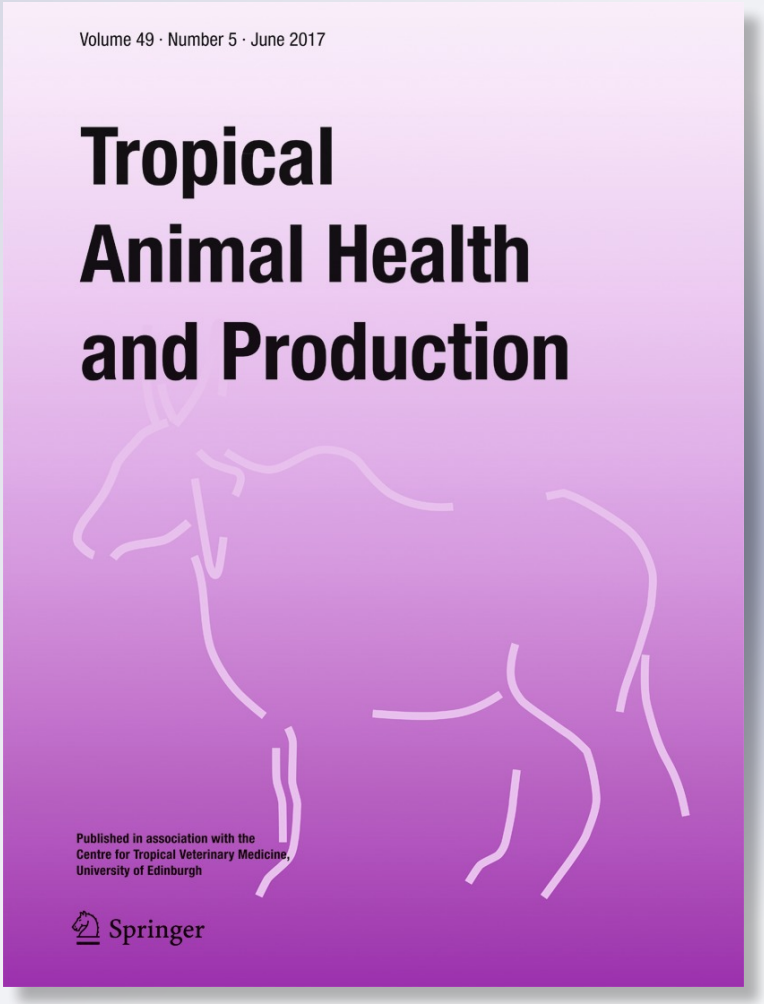
Tropical Animal Health and Production

ISSN 0049-4747
Volume 49
Number 5

Trop Anim Health Prod (2017)
49:923-935
DOI 10.1007/s11250-017-1274-z



Springer

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DOI 10.1007/s11250-017-1274-z

REGULAR ARTICLES

The assessment and the farmers' perceived ranking of feed resources and coping strategies with feed scarcity in smallholder dairy farming in selected district towns of Jimma Zone, Ethiopia

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Received: 13 July 2016 / Accepted: 15 March 2017 / Published online: 8 April 2017

Abstract Inadequate quantity and quality of feed resources are major constraints limiting milk production and reproductive performance of dairy cattle in Ethiopia. The aim of this study was to assess dairy cattle feed resources, feeding practices, the farmers' perceived ranking of feed resources, causes of feed shortage, and coping strategies to feed scarcity in smallholder dairy system in selected district towns of Jimma Zone, Ethiopia. Data were obtained by interviewing 52 randomly selected smallholder dairy farmers using structured questionnaires and through direct observations. Results showed that 20 main feed types used by dairy farmers were identified and categorized into natural pastures, crop residues, green feeds, hay, agro-industrial by-products, concentrate mix, and non-conventional feeds. Overall, natural pasture (mean rank = 0.453), non-conventional feeds (0.307), cut green feeds (0.086), conserved hay (0.076), crop residues (0.049), and concentrate feeds (0.029) were ranked as the main feed resources in decreasing order of importance. Natural pasture grazing (92.2% of the respondents), hay (35.6%), and green feeds (29.4%) were the most important conventional basal feeds used. Wheat bran (11.7% of the respondents) followed by commercial concentrate mix (9.4%), *Noug* seedcake (8.3%), grain (7.8%), and molasses (6.1%) were the concentrate supplements used. Overall, *bulule*-flour mill leftovers (67.2% of the farmers), bean and pea hulls (57.2%) and *atella*-local brew by-product (37.2%), enset (*Ensete ventricosum*, 34.4%), and sugarcane top (32.2%) were the non-conventional feeds available and used during feed scarcity. Barley and *teff* (*Eragrostis teff*) straws and maize and sorghum stovers were the main crop residues used in the dry seasons. Overall, 73.9, 12.2, 12.2, and 1.7% of the respondents practiced free grazing, zero grazing, semi-zero, and a combination of zero- and free-grazing systems, respectively. Over 84% of the respondents in the dry season and 50% in the wet season reported experiencing a shortage of feeds. Poor feed availability (73.9% of the respondents) was reported as the main causes of feed shortage followed by shortage of pastureland (7.8%). Increased use of *bulule* (55.6% of the respondents), crop residues (16.1%), non-conventional feed resources (14.4%), conserved hay (11.1%), purchased green feeds and concentrates (1.1%), and reducing herd size (1.1%) were the farmers' adopted coping strategies to mitigate feed shortage. It is suggested that technical intervention to improve the quality and efficient utilization of the existing feed resources is crucial to enable sustainable feed supply and boost milk production. Technologies that are easy to adopt, feasible, and low cost are also needed to be developed in participatory manner.

Keywords Coping strategies · Dairy production · Feed resources · Feeding practices · Causes of feed shortage

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Introduction

Livestock is a crucial part of agriculture and plays a crucial role in household and national economies of Ethiopia and contributes 12–16% to the nation GDP and 35–40% of the total agricultural domestic product, respectively (Ayele et al. 2003). In addition, livestock provides food, draft power,

income and employment, manure, transport, an asset (store of wealth), escape of poverty in times of crop failure and source of export revenues (Zinash and Tegegne 2000; Ayele et al. 2003). According to the Ethiopian Revenue and Customs Authority report of 2009/2010, livestock and livestock products such as live animals, skins and hides, meat and meat products, and leather and leather products were Ethiopia's fifth most important export commodities next to coffee, oil seeds, gold, and chat (*Catha edulis*) (Access Capital Research 2010). In the report, livestock and livestock products contributed to about 9.1% of the country's total export earnings with a value of about US$182 million.

Ethiopia had the largest cattle population in Africa. According to CSA (2015a), there are 56.71 million cattle, with a ratio of 0.6 heads of cattle/person (Central Statistics Agency (CSA) 2010), and the number of dairy cows of 3 to 10 years is estimated to be 7.8 million. Out of the total cattle population, the female cattle constitute about 55.48%. Recent estimates show that 98.66, 1.19, and 0.14% of the cattle are indigenous, hybrid, and exotic breeds, respectively (CSA 2015a). The cross and exotic breeds represent only 1% of the total cattle population. About 80% of these animals are raised in the intensively cultivated highlands of the country.

Despite the large dairy cattle population, average per capita milk consumption in Ethiopia is about 17 kg/annum as compared to that for Africa which (25 kg), that recommended by World Health Organization (WHO) (200 l), the 62.5 kg recommended by FAO (1990) as a minimum level to be kept for a balanced diet and the world's per capita average of about 100 l/year (FAO 2010). In Ethiopia, the annual growth rate in milk production (2.1%) falls behind the annual human population growth rate of 3.2% (CSA 2006). This shows that there is a huge shortage of milk in Ethiopia to meet the rapidly increasing demand of the population for milk and milk products. To fill the demand gap, dairy products are imported from abroad, and in the years 2005 to 2009, import values increased from about US$5.6 to US$10.3 million (Yilma et al. 2011). In Ethiopia, milk production is greatly depending on indigenous animals. As a result, the development of this sector is failing to satisfy the local demand for livestock products, particularly milk and meat.

Feed shortage in quality and quantity, high disease incidence and parasitic challenges, low genetic potential of indigenous breed, lack of access to land, lack of formal marketing system, and inefficient technical and institutional support are the major constraints contributing to the low productivity of dairy cattle in Ethiopia. Among these constraints, feed shortage was identified as the first key constraint to dairy production (Belachew et al. 1994; Staal and Shapiro 1996; Zelalem 1999; Zegeye 2003; Tefferee 2003; Asaminew and Eyasu 2009; Getinet et al. 2003; Manaye et al. 2009;, Belay et al. 2011).

In Ethiopia, the types of feeds available and the feeding systems are largely a function of agro-ecology, the type of farming system and purpose of livestock production (Zinash and Seyoum 1991). Natural pasture, crop residues, improved pasture, forage crops, agro-industrial by-products, and non-conventional feeds are the livestock feed resources available in Ethiopia (CSA 2012; Alemayehu 2004). Natural pasture (56.23%) and crop residues (30.06%) are the main feed types available in the country (CSA 2015b). The contribution of these feed resources, however, depends up on the agro-ecology, the type of crop produced, accessibility, and production system (Ahmed et al. 2010; Seyoum et al. 2001). The common problems with these resources are marked variation in availability and quality and season shortage, which have been consistently reported as major constraints to ruminant production in the developing countries (FAO 2012).

Although, natural pasture is the major source of feed in Ethiopia, its importance is gradually declining because of the expansion of crop production into grazing lands, redistribution of common lands to the landless, and land degradation (Berhanu et al. 2009). Crop residues such as barely, wheat, teff (*Eragrostis teff*), maize and sorghum stover, finger millet, and rice (Adugna 2007; Berhanu et al. 2009) are mainly fed to animals during the dry seasons. Non-conventional feeds like leaf and stem of banana, fava bean and field pea hulls, enset (*Ensete ventricosum*) leaf and pseudo stem, sugarcane tops, papaya stem, and local brew waste are also fed to dairy cattle (Belay and Janssens 2016). Smallholder dairy farmers in peri-urban and urban areas lack grazing land and depend on purchased feeds.

Before embarking on a feed development program, it is essential to make a holistic inventory of the available feed resources for a specific livestock venture (Wambugu et al. 2011). In view of the variation between agro-ecologies, production systems, seasons, and the farmers' socio-economic profiles in terms of the specific types of feeds used, their sources, and degree of scarcity (Lukuyu et al. 2011), it is essential to consider such factors when making a feed inventory. Feeds and feeding development technologies that incorporate the farmers' socio-economic and agro-ecological circumstances are crucial in designing appropriate feed budgets and sustainable feeding strategies for the smallholder dairy enterprise (Tassew and Seifu 2009). Like other towns in Ethiopia, in the current surveyed secondary towns, population, urbanization, and economic growth are leading to increased demand for animal types of food creating opportunities for smallholder dairy farming to meet the growing demand for milk and dairy products. However, there is no or very limited research works so far conducted to explore the feed resources available for dairy cattle. The objective of the this study was to indentify feed resources, feeding strategies,

the farmers' perceived causes of feed shortage, and coping strategies with feed scarcity for appropriate technical, technological, and institutional interventions in smallholder dairy systems in selected district towns of Jimma Zone, Ethiopia.

Materials and methods

The study area

The study was conducted in the five district towns of Jimma Zone of Oromia Regional State, Ethiopia. The districts are Agaro, Dedo, Mana, Seka Chekorsa, and Kersa, with their respective district administrative towns of Agaro, Seka, Sheki, Serbo, and Yebu, respectively. All district towns were purposively selected based on their location within the Jimma City milk shed; high potential for dairy farming, with capacity for improvement; and easy accessibility. Agaro town is located 45 km west of Jimma City—capital of Jimma Zone. It is situated at 7° 40′–8° 04′ N latitude and 36° 17′–36° 46′ E longitude. Seka is located 18 km southwest of Jimma City and situated at 7° 17′–7° 44′ N latitudes and 36° 17′–36° 42′ E longitudes. Sheki town is 23 km south of Jimma City, and situated at 7° 13′–8° 39′ N latitude and 36° 43′–37° 12′ E longitude. Serbo is located 23 km north of Jimma City, and is situated at 7° 35′–8° 00′ N latitude and 36° 46′–37° 14′ E longitude. Yebu town is 22 km west of Jimma City, and situated at 7° 38′–7° 54′ N latitude and 36° 38′–36° 53′ E longitude. The areas are characterized by a sub-humid climate. The five towns share approximately the same rainfall and temperature with Jimma town, where the annual rainfall ranges from 1400 to 19,00 mm, which is a bimodal with a short rainy season occurring from March to April and main rainy season from June to September. October to end of February is dry season, but the area receives scattered rainfall. The temperature varies between 6 and 17 °C, respectively, and having a minimum temperature of 7 and 31 °C (Alemu et al. 2011).

Sampling procedure

The sampling technique was based on simple random sampling. The target population (sampling frame) for this study was defined as all smallholder dairy farmers in the five district towns who own dairy cattle at the time of this study. A list of 149 smallholder dairy cattle farmers from all the towns was obtained by the help of animal production and/or animal health assistant officers from the respective district livestock development department, and was considered as sampling frame. The sample size required for the study was determined by the formula recommended by Arsham (2005) as follows: $N = 0.25/\mathrm{SE}^2$, where N = sample size and SE = standard error. Considering a standard error of 6.9% (0.069) with 95% CI as follows: $N = 0.25 / (0.069)^2 = 52$ dairy farmers who accounted for 35% of the total number (149) of dairy producers in the area were randomly selected. Thus, 18 farmers in Agaro, 6 in Yebu, 4 in Sheik, 12 in Serbo, and 12 in Seka towns were sampled forming a total sample size of 52 smallholder dairy farmers. Before the formal survey/interview, a preliminary visit was made by the first author and animal production officer or animal health assistant officer of respective districts to get the consent of the farmers, locate the farms, and to give a brief description to respondents on our research objectives and potential benefits of involving in the study. The respondents were well informed that the information obtained from them would not be used against their interest and were requested to give correct information to the questionnaires.

Data collection

Data collection was through individual face-to-face interviews using pre-tested structured questionnaires which consisted of close-ended questions and farm observations. Male or female household heads were involved in the face-to-face interview. The interview was conducted by the first author to avoid bias between interviewees. Animal production or animal health assistant officers of the respective districts were present to support the interview. The questionnaire was prepared in English, and translated into the local "Afaan Oromo" and "Amharic" languages by the principal researcher, who is a fluent in both local languages. The survey questionnaires covered information on feed resources, ranking of feed resources, feeding systems, causes of feed shortage, the farmers' coping strategies to feed scarcity, practice of supplementation, practice of improved forage cultivation, and monthly feed costs.

Statistical analysis

All statistical analyses were performed using Statistical Package for Social Sciences (SPSS) version 16 (SPSS Inc., Chicago, Illinois, USA). The analysis included descriptive statistics (means, frequency distribution, percentages, minimum and maximum values), cross-tabulations, and Pearson chi-squared test of association was employed to compare categorical variables between the five towns. Data including distance of grazing lands and monthly expenses to purchase feeds were analyzed using the ANOVA. To obtain ranking of feed availability, an index was calculated as follows: index = sum (5 × number of responses for the first rank + 4 × number of responses for the second rank + 3 × number of responses for the third rank + 2 × number of responses for the fourth + 1 × number of responses for the fifth) / (5 × total responses for the first rank +4 × total responses for the second rank +3 × total responses for the third rank + 2 × total responses for the fourth rank + 1 × number of responses for the fifth). Rank 1 = is the most available and rank 6 = the least available source of feed.

Results

Feed resources

Table 1 shows the important sources feeds for dairy cattle in the study area. The result showed that 20 different feed types were identified and categorized into natural pasture, crop residues (barely and *teff* (*Eragrostis teff)* straws, maize, and sorghum stovers), hay, green feeds (cut native grass, legume, and forbs), agro-industrial by-products (cotton seedcake, molasses, *noug* seedcake, rice bran, and wheat bran), commercial concentrate, and non-conventional feed resources. Non-conventional feeds in the context of this study are feed resources not normally considered as feed by the farmers and are not readily and regularly available at all times. Availability of hay, green feeds, wheat bran, commercial concentrate mix, sugarcane tops, *bulule* (flour mill leftovers) and faba bean (*Vicia faba*), and field pea (*Pisum sativum*) hull varied between towns surveyed ($P < 0.05$). Overall, among the conventional roughages, natural pasture was reported as the main source of feed (92.2% of the respondents) followed by conserved hay (35.6%), green feeds (29.4%), and crop residues (15.0%) based on seasonal availability in the study area. The available natural pasture was unimproved and mainly adequate during the rainy season.

The identified concentrate feeds were wheat bran (11.7%), commercial concentrate mix (9.4% of the interviewees), *noug* or Niger seed (*Guizotia abyssinica*) cake (8.3%), grain (7.8%), molasses (6.1%), cotton seedcake (5.0%), and rice bran (4.4%). *Noug* or Niger seed is an annual herbaceous plant widely cultivated in the Ethiopian highlands for the edible oil which is obtained by expeller extraction from the small black seeds. The abovementioned concentrate feeds were mainly used by respondents who kept crossbred animals.

Of the major non-conventional feed resources identified, *bulule* (67.2% of the respondents) was the most widely used followed by fava bean and field pea hulls (57.2%), *atella* (local brew by-product; 37.2%), enset (*Ensete ventricosum*) leaf and pseudo stems (34.4%), sugarcane tops (32.2%), and banana leaf and stems (18.9%). Crop residues, hay, and non-conventional feeds were used mainly during the scarcity of feed in the dry season.

Table 1 Major feed resources used by smallholder dairy farmers in the study area (multiple responses allowed, percentage of the respondents in each village, and overall)

Feeds resources	District town						*P*
	Agaro ($n = 18$)	Yebu ($n = 6$)	Sheki ($n = 4$)	Serbo ($n = 12$)	Seka ($n = 12$)	Overall	
Natural pasture	94.4	83.3	100	91.7	91.7	92.2	NS
Crop residues	0.0	0.0	25.0	8.3	41.7	15.0	*
Hay	27.8	33.3	100.0	16.7	0.0	35.6	**
Green feeds	22.2	33.3	75.0	16.7	0.0	29.4	NS
Grains	5.6	0.0	25.0	8.3	0.0	7.8	NS
Noug seed cake	0.0	16.7	25.0	0.0	0.0	8.3	NS
Cotton seed cake	0.0	16.7	0.0	8.3	0.0	5.0	NS
Wheat bran	0.0	0.0	50.0	8.3	0.0	11.7	**
Commercial concentrate	38.9	0.0	0.0	8.3	0.0	9.4	*
Rice bran	5.56	16.67	0.00	0.00	0.00	4.44	NS
Molasses	5.6	16.7	0.0	0.0	8.3	6.1	NS
Brewer's spent grain	11.1	0.0	0.0	0.0	0.0	2.2	NS
Bean and pea hulls	94.4	16.7	100.0	50.0	25.0	57.2	**
Bulule	44.4	66.7	75.0	50.0	100.0	67.2	*
Coffee husk	0.0	16.7	0.0	0.0	0.0	3.3	NS
Enset leaf and stem	22.2	33.3	75.0	16.7	25.0	34.4	NS
Banana leaf and stem	11.1	16.7	0.0	41.7	25.0	18.9	NS
Sugarcane top	77.8	33.3	25.0	8.3	16.7	32.2	**
Atella	44.4	66.7	0.0	41.7	33.3	37.2	NS
Papaya stem	16.7	0.0	25.0	0.	0.0	8.3	NS

P probability, *NS* non-significant, *n* number of respondents

*$P < 0.05$; **$P < 0.01$

The farmers' perceived ranking of feed resources

Table 2 shows the farmers' perceived ranking of available feed resources in terms of importance and availability. The perceived ranking of feeds showed that natural pasture (mean rank = 0.453) was ranked as the first most important feed resource followed by non-conventional feeds (0.307), green feeds (0.086), conserved hay (0.076), crop residues (0.049), and concentrates (0.029) in decreasing order of importance.

Feeding systems

Table 3 represents the different feeding systems practiced by dairy farmers in the study area. The study observed that respondents practiced different feeding practices based on land availability and breed of cattle. The feeding systems showed no significant difference ($P > 0.05$) between towns. Free grazing remains the major system of feeding with over 73% of the respondents reporting it to be the dominant feeding system practiced, as compared to zero grazing (12.2%), semi-grazing (12.2%), and zero grazing coupled with free-grazing (1.7%) systems, respectively.

Means of feed acquisition

Table 4 shows the dairy farmers' means of feed sourcing in the study area. There was no significant difference ($P < 0.05$) in dairy cattle feed acquisition between surveyed towns. The results showed that majority of the respondents (37.8%) obtained cattle feed from own pastureland, whereas 36.1% purchased feed resources in addition to from own grazing lands, 17.8% used only purchased feeds, and the rest 8.3% sourced on public pasturelands and open areas.

Crop residues

Table 5 shows the different types of crop residues used during the dry season in the study area. The study revealed that crop residues are alternative sources of feed resources for dairy cattle, especially in the dry season. Rural smallholder farmers around the surveyed towns practice mixed crop-livestock production, with maize, teff (*Eragrostis teff)*, wheat, sorghum, and barley the main crops grown. In this study, the major crop residues used during the dry season were teff (*Eragrostis teff)* straw (17.2% of the respondents), barely straw (5.0%), maize stover (4.4%), and both maize and sorghum stovers (5.0%).

Improved forage cultivation

Table 6 shows reported practice of improved forage cultivation in the study area. It was observed that majority of the farmers (88.5%) did not practice improved forage cultivation, whereas few (11.5%) respondents practiced forage cultivation. Land shortage (61.5% of the respondents), both land shortage and lack of knowledge on cultivation and utilization (25%), lack of awareness (3.8%), and lack of inputs (1.9%) such as seeds and seedlings were important reasons for not cultivating improved forage in the surveyed areas. From results of this study, land shortage was the most important factor limiting forage cultivation.

Practice of supplementary feeding

Practices of supplementary feeding are presented in Table 7. About 53.9% of the interviewed farmers practiced concentrate supplementation. About 24.4% of the respondents used wheat bran as a major supplementary feed, followed by concentrate mix (18.3%) and bean and pea hulls (4.5%). Dairy farmers in

Table 2 Value index of major feed resources calculated from ranking results of respondents in the study area (percentage of the respondents; $n = 52$)

Variables	Rank					Rank[a] (mean rank)
	First	Second	Third	Fourth	Fifth	
Natural pasture	96.2	0.0	0.0	0.0	0.0	1 (0.453)
Crop residues	0.0	11.5	1.9	0.0	0.0	5 (0.049)
Hay	0.0	11.5	11.5	0.0	0.0	4 (0.076)
Green feeds	3.8	15.4	3.8	0.0	0.0	3 (0.086)
Concentrate feeds	0.0	1.9	3.8	3.8	3.8	6 (0.029)
Non-conventional feeds	0.0	57.7	19.2	17.3	3.8	2 (0.307)
Total	100	98.0	40.2	21.1	7.6	1.00

Index = (5 × number of responses for the first rank + 4 × number of responses for the second rank +3 × number of responses for the third rank + 2 × number of responses for fourth + 1 × number of responses for the fifth) / (5 × total responses for the first rank + 4 × total responses for the second rank + 3 × total responses for the third rank + 2 × total responses for the fourth rank + 1 × number of responses for the fifth)

n number of respondents

[a] The lower the rank of the feed resources, the greater is its importance

Table 3 Percentage of the farmers using different feeding systems in the study area (percentage of the respondents in each town and overall)

Variables	District town						*P*
	Agaro (*n* = 18)	Yebu (*n* = 6)	Sheki (*n* = 4)	Serbo (*n* = 12)	Seka (*n* = 12)	Total	
Feeding system							NS
Zero grazing	11.1	16.7	25.0	8.3	0.0	12.2	
Semi-grazing	11.1	0.00	50.0	0.0	0.0	12.2	
Free grazing	77.8	83.3	25.0	83.3	100.0	73.9	
Zero and free grazing	0.0	0.0	0.0	8.3	0.0	1.7	

NS non-significant, *n* number of respondents

Agaro town (94.4%) used more concentrate supplement than the other towns ($P < 0.05$) due to more number of crossbred cows kept under the zero grazing system. Milking cows (76.7.8% of the respondents) were the most supplemented class of dairy animals, and majority of the respondents (80.7%) purchased concentrate feeds from retailers.

Farmers' perceived causes of feed shortage and coping strategies

Table 8 represents adequacy, causes of feed shortage, and coping strategies to feed shortage in the study area. Inadequate and poor quality feed resources were the most important constraints smallholder dairy farmer in the study area experienced. Natural pasture was the main source of feed augmented with crop residues in the dry season. About 81.7 and 45% of the respondents reported experiencing a shortage of feed in dry and wet seasons, respectively. The main causes of feed shortage in the dry season was mainly low feed availability (73.9% of the respondents) followed by shortage of pasture/grazing land (7.8%). The main causes of feed shortage in the wet season was shortage of grazing land (40.0%), poor feed availability (3.9%), and lack of improved forage (1.1%).

There was a significant difference ($P < 0.05$) in coping strategies adopted to mitigate feed shortage in the dry season between studied towns. Overall, respondents adopted increased use of *bulule* (55.6% of the respondents), crop residues (16.1%), non-conventional feeds (14.4%), conserved hay (11.7%), purchased concentrate and green feeds (1.1%), and reduced herd size (1.1%) as coping strategies against the dry season feed scarcity.

Distance to grazing lands

In the present study, the average distance walked by animals to grazing land from homesteads was 1.09 ± 0.60 km, with a range of 0.20 to 0.35 km, and differed significantly ($P < 0.05$) between Agaro and Seka towns (Table 9).

Monthly feed costs

Feed is a main cost factor in dairy production (Majiwa et al. 2012) making up to 60% of the total daily production cost (Moran 2005). Monthly feed expenses were not significant different ($P < 0.05$ between towns). The overall mean monthly

Table 4 Means of feed acquisition by dairy farmers in the study area (percentage of the respondents in each town and overall)

Variables	District town						*P*
	Agaro (*n* = 18)	Yebu (*n* = 6)	Sheki (*n* = 4)	Serbo (*n* = 12)	Seka (*n* = 12)	Overall	
Feed acquisition method							*
Sourced from own farm	5.6	66.7	0.0	58.3	58.3	37.8	
Purchased	38.9	0.0	25.0	8.3	16.7	17.8	
Purchased and own farm	55.6	16.7	75.0	16.7	16.7	36.1	
Communal grazing	0.0	16.7	0.0	16.7	8.3	8.3	

n number of respondents

*$P < 0.05$

Table 5 Respondents who used different sources of crop residues in the study area (percentage of the respondents in each village and overall)

Variables	District town						*P*
	Agaro (*n* = 18)	Yebu (*n* = 6)	Sheki (*n* = 4)	Serbo (*n* = 12)	Seka (*n* = 12)	Overall	
Teff straw	11.1	0.0	50.0	0.0	25.0	17.2	*
Barely straw	0.0	0.0	25.0	0.0	0.0	5.0	
Maize stover	5.6	16.7	0.0	0.0	0.0	4.4	
Maize and sorghum stover	0.0	16.7	0.0	8.3	0.0	5.0	

n number of respondents

*$P < 0.05$

feed expense per household was 200.38 ± 43.72 Ethiopian birr (ETB), which is about US$10 (Table 10).

Discussion

In the present study, majority of the respondents (92.3%) depended on natural pasture from private, communal, and open space grazing lands. Natural pasture in the communal grazing lands and green feeds were adequately available in the wet season, but are insufficient in the dry season. The result of our study was in agreement with previous findings (Gillah et al. 2013; Reynolds et al. 1993; Muinga et al. 1999) who reported that natural pasture was the main feed resource that smallholder dairy farmers used. In dry seasons, natural pasturelands were overgrazed and degraded due to uncontrolled grazing practices. This was attributed to lack of improved grazing management technologies, in which there was no control over access and number of cattle, as all cattle owners compete for the available communal pasturelands.

In the study area, conserved hay, crop residues and non-conventional feeds were mainly used in the dry season (October to February) when availability of natural pasture and green feeds decline. In Ethiopia, crop residues provide the major feed resources in the dry season. However, in the current study, crop residues were used by small proportion of respondents due to lack of knowledge on their importance in minimizing feed shortage in the dry season and due to lack of land for crop production. The practice of haymaking was also found to be low among the respondent farmers (25% of the respondents) due to lack of awareness and low availability of grasses from communal grazing lands. Those farmers who practiced hay conservation said that shortage of labor and storage facilities, and financial limitations to purchase grasses from schools and government offices, was the main challenges in haymaking, and this calls for adoption of simple and low cost technologies and credit services.

In the current study, a small proportion of the respondents who owned crossbred animals used commercial concentrate and agro-industrial by-products. Even though farmers in the

Table 6 Percentage of the farmers who practiced improved forage cultivation in the study areas (percentage of the respondents in each village and overall)

Variables	District town						*P*
	Agaro (*n* = 18)	Yebu (*n* = 6)	Sheki (*n* = 4)	Serbo (*n* = 12)	Seka (*n* = 12)	Total	
Improved forage cultivation							NS
Yes	16.7	0.0	0.0	25.0	0.0	8.3	
No	83.3	100.0	100.0	75.0	100.0	91.7	
Reasons for not cultivating improved forage							*
Land scarcity	61.11	50.00	50.00	50.00	66.67	55.56	
Lack of inputs	0.00	0.00	0.00	0.00	8.33	1.67	
Lack of awareness	0.00	33.33	0.00	0.00	0.00	6.67	
Land scarcity and lack of knowledge	22.22	16.67	50.00	25.00	25.00	27.78	

NS non-significant, *n* number of respondents

*$P < 0.05$

Table 7 Frequency (percentage) of respondents practicing supplementary feeding in the study area (percentage of the respondents in each village and overall)

Variables	District town						
	Agaro (n = 18)	Yebu (n = 6)	Sheki (n = 4)	Serbo (n = 12)	Seka (n = 12)	Overall	P
Practice of concentrate supplementation							**
Yes	94.4	50.0	50.0	41.7	33.3	53.9	
No	5.6	50.0	50.0	58.3	66.7	46.1	
Type of concentrate supplemented, multiple responses allowed							**
Noug seedcake	0.0	0.0	0.0	0.0	8.3	1.7	
Wheat bran	5.6	16.7	50.0	25.0	25.0	24.4	
Concentrate mix	83.3	0.0	0.0	8.3	0.0	18.3	
Bean and pea hulls	5.6	16.7	0.0	0.0	0.0	4.5	
All types	0.0	16.7	0.0	0.0	8.3	5.0	
Salt	100	100	100	100	100	100	
Class of animals supplemented, multiple responses allowed							NS
Milking cows	83.3	50.0	75.0	91.7	83.3	76.7	
Lactating cows and female calves	11.1	16.7	25.0	0.0	8.3	12.2	
Milking cows, heifers, and female calf	0.0	16.7	0.0	8.3	0.0	5.0	
All animal types	0.0	0.0	0.0	0.0	8.3	1.7	
Milking and pregnant cows, heifers, and female calf	0.0	16.7	0.0	0.0.	0.0	3.3	
Milking cows and all calves	5.5	0.0	0.0	0.0	0.0	1.1	
Means of concentrate sourcing, multiple responses allowed							**
The farmers' cooperative	16.7	0.0	0.0	0.0	0.0	3.3	
Feed traders	33.3	100	100	100	100	86.7	
Feed industries	5.6	0.0	0.0	0.0	0.0	1.1	
Farmer cooperative and traders	44.4	0.0	0.0	0.0	0.0	8.9	

NS non-significant, *n* number of respondents

**$P < 0.01$

study area were well aware of the feeding value of concentrates in increasing milk yield, the unaffordable price and poor availability limited their wide utilization. In contrast to the results of this study, commercial concentrate and agro-industrial by-products were used by a higher number of peri-urban and urban smallholder dairy farmers in Ethiopia (Belay and Janssens 2016; Girma et al. 2014).

Among the non-conventional feed resources that form the basal diets of animals, majority (63.5%) of the respondents used *bulule* followed by faba bean and field pea hulls, *atella*, sugarcane tops, enset (*Ensete ventricosum*) pseudo stems, and banana stems. The practice of supplementing lactating cows with feed sources as energy and protein source in the present study was in agreement with previous works (Belay and Janssens 2016; Girma et al. 2014; CSA 2012; Yosef et al. 2002). Due to financial limitations, most respondents used *bulule*, bean and pea hulls, and *atella* as substitute to conventional concentrates. The frequent use of non-conventional feed resources in this study was due to their cheap price and adequate availability throughout the year.

In this study, the farmers' ranked natural pasture as the first most important feed resources and this was attributed to its relative availability throughout the year. However, the quantity and quality varies based on season, whereby it is adequately available during the wet season, but declines in both quantity and quality during the dry season. The non-conventional feeds were ranked as the second most important feeds. This was due to their frequent availability both in the dry and in the wet seasons. Cut green feeds were ranked as the third most important dairy feed in the study area due to their adequate availability, especially in the wet season, but the availability and quality decline during the dry season. Concentrate feeds were ranked by the respondents as the least important feed resource due to their unaffordable costs and poor availability. This reflects the need for improved access to credit services to be able to

Table 8 The farmers' perceived causes of feed shortage and coping strategies in the study area (percentage of the respondents and overall)

Parameters	Districts town						*P*
	Agaro (*n* = 18)	Yebu (*n* = 6)	Sheki (*n* = 4)	Serbo (*n* = 12)	Seka (*n* = 12)	Overall	
Do you experience feed shortage in the dry season?							NS
Yes	83.3	66.7	75.0	91.7	91.7	81.7	
No	16.7	33.3	25.0	8.3	8.3	18.3	
Causes of feed shortage							NS
Poor availability	77.8	50.0	75.0	91.7	75.0	73.9	
Shortage of land	5.6	16.7	0.0	0.0	16.7	7.8	
Coping strategies for the dry season feed shortage (multiple responses allowed)							**
Conserve hay	0.0	33.3	25.0	0.0	0.0	11.7	
Use green feed and concentrates	5.6	0.0	0.0	0.0	0.0	1.1	
Use crop residues	55.6	16.7	0.0	8.3	0.0	16.1	
Reduce herd size	5.6	0.0	0.0	0.0	0.0	1.1	
Use *bulule*	27.8	50.0	75.0	50.0	75.0	55.6	
Use non-conventional feeds	5.6	0.0	0.0	41.7	25.0	14.4	
Do you experience feed shortage in the wet season?							NS
Yes	66.7	50.0	25.0	25.0	58.3	45.0	
No	33.3	50.0	75.0	75.0	41.7	55.0	
Causes of feed scarcity							NS
Poor feed availability	11.1	0.0	0.0	0.0	8.3	3.9	
Lack of improved forage	5.6	0.0	0.0	0.0	0.0	1.1	
Shortage of grazing land	50.0	50.0	25.0	25.0	50.0	40.0	

NS non-significant, *n* number of respondents

**$P < 0.01$

purchase concentrate feeds to improve milk production of dairy cows.

In the present study, four systems of feeding, which are practiced by the dairy farmers to feed their cattle, were identified. Free or extensive grazing was the dominant feeding system, followed by zero, semi-zero, and both zero- and free-grazing systems. This result was in line with previous findings (Belay and Janssens 2016; Feyissa et al. 2014; Tegegne et al.

Table 9 Mean (±SE) of distance of grazing lands from homesteads in the study area

District	Distance			
	n	Mean ± SE	Minimum	Maximum
Agaro	18	0.97a ± 0.03	0.50	1.00
Yebu	6	1.00ab ± 0.00	1.00	1.00
Sheki	4	1.00ab ± 0.00	1.00	1.00
Serbo	12	1.08ab ± 0.08	1.00	1.00
Seka	12	1.35b ± 0.23	0.20	3.50
Overall	52	1.09 ± 0.60	0.20	3.50
P		0.260		

Means with different lowercase letters in the same column are significantly different at $P < 0.05$

n number of respondents

Table 10 Mean (±SE) of monthly feed expenses per household (ETB) in the study area

District	Distance			
	n	Mean ± SE	Minimum	Maximum
Agaro	18	180.00 ± 20.55ab	20.00	400.00
Yebu	6	3.33 ± 3.33a	0.00	20.00
Sheki	4	425.00 ± 14.93b	100.00	800.00
Serbo	12	220.83 ± 12.56ab	0.00	1500
Seka	12	234.17 ± 12.70ab	0.00	1500.00
Overall mean	52	200.38 ± 43.72	0.00	1500
P value		0.334		

Means with different lowercase letters in the same column are significantly different at $p < 0.05$

n number of respondents

2013; Gillah et al. 2013; Gillah et al. 2012; Embet 2006), who reported that the feeding systems observed in this study were also practiced in peri-urban and urban smallholder dairy systems in east Africa. The results of the study revealed that free grazing was practiced during both wet and dry seasons. Where both zero and free grazing were practiced, crossbred animals are mainly confined but occasionally let out to graze. Zero grazing/stall feeding was the least practiced feeding system in the studied area. In this feeding system, the animals were totally confined and fed by cut-and-carried feeds, and were mainly practiced by crossbred owners. The reasons why the owners of crossbred animals mostly preferred zero grazing was to reduce disease challenges, especially tick infestation. Even though the respondents widely practiced extensive grazing system, there was serious dwindling of public grazing lands surrounding the study towns as more of it was redistributed to jobless youth for micro-enterprises, housing, private investments, and public infrastructures.

In the current study, most farmers (80.8%) provided supplementary feeds mainly to lactating cows. This was in agreement with the finding of Belay and Janssens (2016) who reported that 94.4% of the smallholder dairy farmers in Jimma town provided concentrate supplements primarily to their lactating cows. However, farmers provided equal quantity of concentrate supplements to all lactating cows, regardless of milk yield, physiological stage, and body condition, which is in agreement with earlier reports (Belay and Janssens 2016). This practice calls for technical intervention and training of farmers on how to supplement lactating cows based on their milk yield and physiological status; otherwise, high yielding cows will be affected when receiving equal rates of supplementary feeds with low yielding cows. This practice of supplementation will in turn reduce the income of the farmers. In addition to concentrates, few farmers also supplemented their lactating cows with fava bean and field pea hulls. Common salt was supplemented by all respondents as source of mineral, particularly during the dry season to increase feed intake and enhance reproductive performance, particularly onset of estrus. Salt is usually provided by mixing it with *atella* and *bulule*. Respondent farmers mentioned that animals with mineral deficiencies are licking soil, eating clothes, and search for human urine. This coincides with scientific symptoms of mineral deficiencies in livestock.

In this study, land shortage was frequently reported as the most important cause of feed shortage. This is in agreement with previous reports (Abate et al. 2012; Belay et al. 2012; Geleti et al. 2014b) in different parts of Ethiopia. The farmers' adopted coping strategies to feed scarcity found in the present study were in agreement with earlier report (Belay and Janssens 2016) in Jimma town, Ethiopia. Increased use of *bulule*, crop residues, non-conventional feeds, conserved hay, purchased concentrates and green feeds, and reducing herd size based on seasonal feed availability were the most important coping strategies used by farmers in the study area to mitigate feed scarcity. Respondents indicated that at times of feed shortage, they utilized whatever feed resources were available without preferences.

Barley, maize, sorghum, teff, and wheat are the main crops grown by mixed crop-livestock farmers surrounding the surveyed towns. Despite the abundant availability of the crop residues, only small proportion of farmers in the study area used them. This was due to lack of knowledge on their importance to maximize feed availability to ease feed scarcity. Barley straw was only used by dairy farmers from the highland area (Sheki town), whereas teff, maize, and sorghum are available in all surveyed towns. Relatively, teff straw was economically the most important crop residue. In addition to source of feed, teff straw is used for padding/plastering houses and used as a source of income. In contrast to the findings of the present study, crop residues such as barely, wheat, teff, maize and sorghum stover, finger millet, and rice were widely utilized for feeding dairy cattle in the dry season in different parts of Ethiopia (Adugna 2007; Birhanu et al. 2009; Abate et al. 2012; Duguma et al. 2012; Geleti et al. 2014b; Girma et al. 2014).

Despite the wide availability of crop residues, respondents lack awareness and knowledge of the importance and proper utilization of these feed resources. This deserves technical assistance and strong extension services. If properly collected and stored, crop residues would reduce the problem of prevailing feed shortage in the dry season.

When asked, the respondents said that labor shortage for transportation and lack of storage facilities were the limiting factors to their efficient utilization. It was observed that most of the crop residues were left in situ with a lot of wastage and finaly burnt before land preparation for the upcoming cropping season. Teff straw is exceptional, in which it is sold as construction material for plastering newly constructed houses in addition to its use as animal feed. The major constraints to the use of crop residues are their low energy, protein and minerals contents, and less digestibility and low intake.

Improved technologies, such as energy and protein supplements, treatment with alkaline chemicals (ammonium and sodium hydroxides), urea treatment, use of forage legumes, and chopping could improve the intake, digestibility, and nutritional value of crop residues. It was reported that chopping can considerably reduce the intake problem for animals fed large amounts of crop residues (Methu 1998). The other affordable and visible technology is urea treatment and mixing with molasses to improve their nutritional value. In general, the study strongly suggests the training of farmers on treatment of crop resides with cost-effective, feasible, and affordable technologies to increase their feeding value and hence help to reduce feed shortages during the dry season. Of course, provision of credit services would be crucial to purchase the improved technologies.

In agreement with our result, Altaye et al. (2014) reported that 95% of the interviewed households from Metekel Zone in Ethiopia did not practice cultivation of improved forage species. But, in disagreement with our finding, about 76% of the respondents in Wolaita Zone (Zereu and Lijalem 2016) and 72.4% of the respondents in the central highlands of Ethiopia (Altaye et al. 2014) practiced forage cultivation. In the current study, the reasons for not growing improved forage were scarcity of land, lack of awareness and inputs. This is in agreement with previous reports of Zereu and Lijalem (2016) and Assefa et al. (2015) in different parts of Ethiopia. Where land is available supplying farmers with forage seeds, seedlings and cuttings with technical advice would help in reducing feed shortage.

The findings of the current study suggest the need to initiate comprehensive extension services and training farmers on improved technologies of forages and multipurpose fodder tree production. Farmers should also be trained on improved forage development strategies, such as inter-cropping/alley farming and under sowing with cereal crops and fruits trees and establishment of fodder banks. These forage development strategies would not only reduce competition for land between cereal crops and forages but also improve feed availability and quality resulting in increased animal performance. Tree legumes have high protein content which meets both the microbial requirements for increased fermentation of the basal diet and amino acids for the host animal (Leng 1992). Tree legumes are also used for other purposes such as firewood, construction, food, fencing, windbreak, and medicines (Devendra 1993).

In the current study, the farmers said that there was no variation between wet and dry seasons in distance moved to grazing pasturelands. This is due to the reason that farmers use limited areas of public and open grazing lands found surrounding the towns. In contrast to the findings of the present study, farmers in Dar es Salam city and Morogoro town of Tanzania covered a distance of 14.7 ± 1.2 and 3.06 ± 1.2 km, respectively, in search of forage (Gillah et al. 2013).

The overall feed cost per household per month reported in this study was lower than the 1914.26 ± 209.04 ETB/month in Jimma town area (Belay and Janssens 2016). This could be due to the fact that almost all smallholder dairy farmers in Jimma town kept crossbred dairy cows in their residential compounds, practiced zero grazing, and depended on purchased feeds.

Conclusion

In conclusion, this study assessed feed resources, feeding practices, causes of feed shortage, and coping mechanisms to mitigate feed shortage and the farmers' perceived ranking of identified feed resources which would help to develop strategies to enhance smallholder dairy cattle production in the surveyed area. The results would be helpful to researchers, decision makers, government institutions, and development agencies in devising appropriate policy and planning feed development projects. Farmers ranked natural pasture, non-conventional feeds, green feeds, native grass hay, crop residues, and concentrate feeds in that order of importance as the main feed resources available for feeding dairy cattle based on seasonal availability. Natural pasture and cut green feeds were considered to be abundant during the wet season, while crop residues and non-conventional feeds were the potential feed resources during periods of feed shortages, particularly in the dry season. Low feed availability and shortage of grazing land were reported as the main causes of feed shortage. Increased uses of the available feed resources were the farmers' coping strategies to mitigate feed shortages and to meet nutritional requirements of dairy cattle. From the results of this study, it is suggested that to ensure increased and sustainable milk production through increased productivity of dairy cows in the surveyed area, it is essential to improve the utilization of locally available feed resources in quality and quantity on sustainable basis through improved and appropriate technologies such as simple and cheap pasture improvement and management strategies; maximized hay conservation, on farm feed formulation from locally available feed resources; cultivation of improved forages; improved feeding strategies; efficient utilization of locally available feed resources; collection, proper storage and treatment of crop residues; and supplementation of affordable commercial concentrate and agro-industrial by-products. These need to be developed through comprehensive technical and institutional interventions involving participation of dairy farmers.

Acknowledgments The authors gratefully acknowledge the financial support from the VLIR-UOS institutional university cooperation (IUC-JU) program for supporting this study. We are also grateful to the smallholder dairy farmers in the five district towns of Jimma Zone who participated in the study, for their time and information. We sincerely thank the animal health assistants and animal production officers of the respective districts for their support.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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