Prevalence and associated economic loss of fetal wastage in small ruminants slaughtered at Addis Ababa municipality abattoir, Ethiopia

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Abstract

The study examined prevalence and economic implications of abattoir pregnancy/ fetal wastage in small ruminants. Survey was conducted on ewes (n=201) and does (n=183) slaughtered at Addis Ababa municipality abattoirs, during December 2017 and January 2018. Female reproductive tracts were examined for presence and types of pregnancy and/or gross disorders. Net economic loss and net economic risk due to abattoir fetal wastage were calculated for each species after accounting for naturally expected abortion and neonatal losses, and domestic net market values. One hundred forty-two (37 %) animals were pregnant 131 (34.1 %) with single and 11 (2.9 %) with twin fetus. A total of 153 fetuses were recovered giving a fetal wastage prevalence of 39.8 %. More animals in the second trimester (25.5 %) were slaughtered than those in first (8.3 %) or third (3.1 %) trimesters (p < 0.05). Prevalence of pregnancy was 32.8 % in does and 40.8 % in ewes (p = 0.104). Prevalence of fetal wastage was 37.2 % (68 fetuses) and 42.3 % (85 fetuses) in goats and sheep, respectively (p > 0.05). Abattoir pregnancy prevalence showed variations relative to slaughter month in goat (p < 0.01) and body condition in sheep (p < 0.05). Observed abattoir pregnancy prevalence levels incurred net economic loss of 313.55 USD in sheep (per 201 ewes) and 315.4 USD in goats (per 108 doe). This translated to net economic risk of 1.7 USD per mature doe or ewe slaughtered for meat. Nine (4.9 %) does and 1 (0.5 %) ewe showed gross reproductive tract disorders (p < 0.05). Frequent female slaughter without efficient ante-mortem pregnancy screening predisposed significant proportion of small ruminants to pregnancy/fetal wastage. Deeper investigations are needed to understand reasons behind pregnant small ruminant slaughter and to mitigate its negative impacts on sustainability of animal production. Evaluating and capacity building on alternative small ruminant pregnancy diagnosis methods requires due attention.
Key words: Doe; Pregnancy; Reproductive disorders; Ewe; Fetal wastage; Economic implication; Abattoir

Introduction

Ethiopia owns 30.7 million sheep and 30.2 million goats (CSA, 2017). Small ruminants account for a quarter of domestic annual meat consumption as well as over 90% of live animals and meat exported annually from the country. However, national off-take rate, carcass yield and per-capita consumption for mutton (33-40%, 10 kg and 1.3 kg) and goat meat (27-35%, 8 kg goat, and 1.3 kg), respectively, are very low even by sub-Saharan Africa standards. In absence of tangible productivity gains, rapidly growing local demands for meat are driving sustained increase of annual small ruminant slaughter volumes in Ethiopia (Legese and Fadiga, 2014; Shapiro et al., 2017; Eshetie et al., 2018).

Across sub-Saharan Africa, similar pressure to meet rising human demand for meat has been linked to significant pregnant livestock slaughter and fetal wastage which seriously undermine sustainable animal protein production. In part, later trends reflected effects of farmers economic and husbandry limitations and weak slaughter regulation (Abassa, 1995; Tizhe et al., 2010; Fayemi and Muchenje, 2013). There are several methods of small ruminant pregnancy diagnosis with choices depending on gestation stages and level of expertise and technical inputs available. Real time ultrasonography is by far the most reliable method followed by plasma or milk progesterone analysis. More advanced accurate pregnancy detection methods are often used in modern small ruminant operations of developed regions but remain inaccessible in most tropic extensive farming systems (Noakes et al., 2001; Tamassia, 2007; Ptaszynska, 2009). Hence, unknowing farmer dispatch of pregnant stock to slaughter could be substantially lower in developed regions.

Considerable risk of small ruminant fetal wastage is highly likely in Ethiopian contexts. Annual domestic female small ruminant (mainly replacement stocks) slaughter shares increased from 26.6% (1.26 million) to 29.1% (1.92 million) in past decade alone (CSA, 2008; CSA, 2017). Ethiopia’s Meat Inspection Regulation (Section 2 Article 10.3.) indicated recommends that pregnant animals should be withheld from slaughter at ante-mortem examination (MoA, 1993). Still, uncontrolled small ruminant breeding (Abebe, 2008) and slaughter (Legese and Fadiga, 2014; Mummad and Webb, 2015) systems typical across the...
country make it doubtful that females destined for meat undergo formidable pregnancy screening. Accordingly, high levels of abattoir pregnancy and fetal wastage were reported in sheep (> 70 %) and goats (47 %) from the central highlands (Mukasa-Mugerwa and Tekelye, 2003; Tamirat et al., 2015). However, situation of small ruminant abattoir fetal wastage at Addis Ababa, probably the largest urban meat consumer market in Ethiopia, is unknown. Therefore, this study explored prevalence pregnancy/ fetal wastage and associated economic losses in doe and ewes slaughtered at Addis Ababa municipality abattoir. Further interest was on describing type and prevalence of gross female reproductive disorders.

Materials and methods

Study area

Addis Ababa is the capital and administrative center of Federal Democratic Republic of Ethiopia. The city is located on 9°1’48’ N latitude, 38° 44’ 24’ E longitude and average altitude of 2,400 meters above sea level. Addis Ababa city has an estimated land cover of 530.14 square kilometers and population density of 5,165.1 inhabitants per square kilometer. It has a cool humid climate with bimodal annual rainfall averaging 1800 mm and average daily temperature ranging from 10.7 to 25.6 °C (Beshada, 2012; Assefa et al., 2017).

Study population

The study population comprised of mature does and ewes slaughtered at Addis Ababa municipality abattoir. This facility is over 60 years old and was reported to slaughter 36,000 sheep and 18,000 goats in a year (Assefa et al., 2017). Recent slaughter statistics stratified by sex and age proved difficult to access. Slaughter animals are supplied to Addis Ababa city from different parts of Ethiopia including; Northwest, west, Northeast, east and south west in decreasing order of shares (Beshada, 2012). This represents diverse highland and lowland small ruminant production systems in the country.

Study design and variables

Cross-sectional abattoir survey was conducted to explore pregnancy, fetal wastage and gross reproductive disorders in mature does and ewes slaughtered at
Addis Ababa municipality abattoir during December 2017 and January 2018. Outcomes of interest were abattoir pregnancy/ fetal wastage prevalence (number of pregnant females/ fetuses divided by total female examined x 100), and associated net economic losses (NEL) and net economic risks (NER) as well as prevalence (affected/ examined females x 100) and types of gross female reproductive disorders. The independent variables included animal species, body condition and study months.

**Sampling method and sample size**

Thirty abattoir survey dates were selected by random lottery method in December 2017 (16) and January 2018 (14). Abattoir was visited from 5 PM to 10 PM and all mature does and ewes slaughtered at this time were sampled. Sample size (n) was calculated using the formula by Thrusfield (2015) for simple random samples with 50 % expected prevalence (Pexp), 5 % desired precision level (d) and 95 % confidence level (α= 0.05). Accordingly, 384 study animals were sampled including 183 does and 201 ewes. Average daily frequency of study animals was 12 during December 2017 (6 doe and 6 ewes) and 14 in January 2018 (8 doe and 6 ewes).

**Abattoir study methods**

Ante-mortem examination of small ruminant at the study abattoir was limited to inspection for physical problems and no reliable pregnancy screening system was in place. On slaughter floor, female small ruminants were checked for maturity based on presence of more than 2 pairs of permanent incisors. Body condition of study animals was subjectively classified as thin, medium and fat according to ESGPIP (ESGPIP, Technical Bulletin No. 8). Post mortem, female reproductive tracts were harvested intact and examined by inspection, palpation and uterine incision to detect pregnancy and/ or gross disorders (e.g. pyometra denotes uterine lumen distended with pus and imminent abortion referred to abnormal appearance of fetal fluids, fetus and placenta indicative of pregnancy disruption). In pregnant females, liter size was recorded and crown - rump length (CRL) of largest fetus was measured (cm) using measuring tape or ruler as previously described (Tamirat et al., 2015). Fetal age (FA) or gestation length (GL) was calculated (in days) from CRL measurement using recommended formulas (Sivachelvan et al., 1996; Hussein, 2008). Based on the estimated FA/ GL, stage of pregnancy was classified in to 1st (< 50 days), 2nd (50 to 100 days) and 3rd (> 100 days) trimester.
Sheep GL/FA (in days) = 2.1 (CRL + 17) &
Goat GL/FA (in days) = (2.74 x CRL) + 30.15

In pregnant small ruminants, month of fertile mating was approximated by counting back GL/FA days from date of abattoir detection. Corresponding parturition months were estimated by counting forward from abattoir detection date the difference between average small ruminant gestation length (150 days) and calculated GL/FA (n days).

**Economic analysis**

Economic impact of fetal wastage reflects financial value of potential offspring’s forgone due to slaughter of pregnant female animals for human meat consumption. This study drew on abattoir fetal wastage economic loss estimation methods that account for naturally expected abortion/stillbirth and neonatal mortality losses described by other studies (Tamirat et al., 2015; Kashoma and Melkiory, 2017). The approach was modified by considering net market return values (gross value – rearing costs) of sheep and goats in Ethiopia so as to estimate net economic loss (NEL) due to pregnancy/fetal wastage for total animals examined as outlined below.

NEL (Birr) = NMRV (Birr/Animal) x VOW (n Animals) where;

NMRV stands for net market return value of sheep (223.0) and goats (267.3) in Ethiopia calculated by averaging values reported by Shapiro et al. (2017).
VOW denotes net quantity of viable offspring’s wasted due to observed abattoir pregnant slaughters. This was calculated by deducting naturally expected abortion/stillbirth and neonatal mortality losses from observed abattoir pregnancy/fetal wastage levels in each small ruminant species as outlined below.

VOW (n) = Live Born Offspring (n) – Premature Offspring Mortality (n)

Live born offspring (n) = (n) Pregnant females (Total – Abortion/Still birth) X Average liter size (n)

Abortion/Still birth (n) = Total pregnant females (n) X Expected abortion/still birth prevalence (%)
Expected abortion/ still birth prevalence (ExpASbP) was approximated by averaging previous national estimates (Fentie et al., 2016) for goats (16.8 %) and sheep (14.7 %)

Premature offspring mortality (n) = Live born offspring (n) X Expected offspring mortality prevalence (%)

Expected offspring mortality prevalence (ExpOMP) was approximated to 18.8 % for both goats and sheep by averaging national estimates reported by Fentie et al. (2016) and CSA (2017)

To appreciate current NEL projections on larger slaughter volumes, the study calculated net economic risk (NER) which reflects pregnancy/ fetal wastage related financial loss risk expected when 1 mature doe or ewe is slaughtered for human consumption. For each small ruminant species, NER (Birr or USD/ mature female slaughtered) was calculated by dividing NEL with total number of females examined (n).

Data analysis

Study months, animal species and body condition, gross reproductive disorder (presence and type) and pregnancy (presence, liter size and CRL (cm), FA/ GL (days), gestation stage) observations were recorded and/ or calculated on Microsoft Excel Sheet. Economic loss (Birr/USD) calculations were done on a separate Microsoft Excel sheet using built in arithmetic functions on combination of observed and referred input variables. Further statistical analysis was carried out on SPSS version 16 software. Categorical variables were summarized in frequency (n (%)) tables and frequency distribution of fertile mating months was contrasted using line graphs with 95 % confidence interval (CI). Numerical variables (CRL and FA/ GL) were summarized using mean ± standard error. Association between categorical factors and outcomes was analyzed using Chi-square and Fisher exact tests. Relationship of numerical and categorical variables was evaluated by comparison of means using 95 % confidence interval (CI). Statistical significance was set at $p < 0.05$. 
Results

Pre-slaughter 17 (4.4 %), 170 (44.3 %) and 197 (51.3 %) animals exhibited thin, medium and good body conditions, respectively ($p < 0.05$). Post-mortem reproductive examination revealed that 142 (37 %) female small ruminants were pregnant with single (34.1 %) and twin (2.9 %) fetus ($p < 0.05$). A total of 153 fetuses were recovered giving an overall abattoir fetal wastage prevalence of 39.8 %. Prevalence of pregnant slaughter was 32.8 % in does and 40.8 % in ewes (Chi-square = 2.64, $p = 0.104$). Twin pregnancy was higher (Chi-square = 4.54, $p = 0.033$) in does (4.4 %) than in ewes (1.5 %). Overall prevalence of fetal wastage was 37.2 % (68 fetuses) in goat and 42.3 % (85 fetuses) in sheep (Chi-square = 1.53, $p = 0.216$).

Fetal CRL and calculated FA/GL varied widely amongst pregnant small ruminants but showed limited average variation in relation to animal species (Table 1). More pregnant small ruminants were in second trimester (25.5 %) compared to counterparts in first (8.3 %) and third (3.1 %) trimesters ($p < 0.05$). Likewise, more fetuses were lost from second trimester pregnancy (27.1 %) than either first (9.4 %) or third (3.4 %) trimester pregnancies ($p < 0.05$). Prevalence patterns of pregnancy and fetal wastage at different trimesters were consistent in goats and sheep (Table 1).

Table 1. Fetal length, age, gestation stage in pregnant small ruminants slaughtered at Addis Ababa Municipal abattoir

<table>
<thead>
<tr>
<th>Variable</th>
<th>Statistics/Categories</th>
<th>Total (N=140)</th>
<th>Goat (N=60)</th>
<th>Sheep (N=82)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRL (cm)</td>
<td>Min-Max</td>
<td>3 - 35</td>
<td>3 – 34</td>
<td>4 – 35</td>
</tr>
<tr>
<td></td>
<td>Mean ± SE</td>
<td>15.34 ± 0.70</td>
<td>13.4 ± 1.05</td>
<td>16.75 ± 0.91</td>
</tr>
<tr>
<td></td>
<td>95 % CI, LB-UB</td>
<td>13.96 – 16.72</td>
<td>11.29 – 15.51</td>
<td>14.95 – 18.56</td>
</tr>
<tr>
<td>FA / GL (Days)</td>
<td>Min-Max</td>
<td>42 – 109.2</td>
<td>42 – 107.1</td>
<td>44.1-109.2</td>
</tr>
<tr>
<td></td>
<td>Mean ± SE</td>
<td>67.91 ± 1.5</td>
<td>63.8 ± 2.21</td>
<td>70.89 ± 1.91</td>
</tr>
<tr>
<td></td>
<td>95 % CI, LB-UB</td>
<td>65.01 – 70.81</td>
<td>59.42 – 68.26</td>
<td>67.09 – 74.68</td>
</tr>
<tr>
<td>Pregnancy n (%)</td>
<td>1st Trimester</td>
<td>32 (8.3)</td>
<td>17 (9.3)     b 15 (7.5)     a</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2nd Trimester</td>
<td>98 (25.5)</td>
<td>39 (21.3)    a 59 (29.4)    a</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3rd Trimester</td>
<td>12 (3.1)</td>
<td>4 (2.2)      b 8 (4)        a</td>
<td></td>
</tr>
<tr>
<td>Fetal Wastage n (%)</td>
<td>1st Trimester</td>
<td>36 (9.4)</td>
<td>20 (10.9)     b 16 (8)      b</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2nd Trimester</td>
<td>104 (27.1)</td>
<td>44 (24)      a 60 (29.9)    a</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3rd Trimester</td>
<td>13 (3.4)</td>
<td>4 (2.2)      b 9 (4.5)      b</td>
<td></td>
</tr>
</tbody>
</table>

Superscripts a, b, c indicate frequency variations of different categorical outcome levels in specific species at $p < 0.05$. 

Approximated fertile mating (conception) time of pregnant small ruminants was higher \( (p < 0.05) \) around October (38.7%) and November (38%) than in September (6.5%) and December (2.1%). Corresponding expected parturition (lambing/ kidding) dates concentrated \( (p < 0.05) \) during March (46.5%) and April (34.5%) than in February (4.7%) and May (2.3%). Respective temporal reproductive variations were consistent in pregnant does and ewes (Figure 1 a, b).

![Figure 1](image)

**Figure 1.** Fertile mating (a) and parturition (b) months relative to species of pregnant animals

On the other hand, 10 (2.6%) female small ruminants exhibited gross reproductive disorders including pyometra (1.6%) and signs of abortion \( (\text{hemorrhagic turbid fetal fluid and/or placental lesions}) \) in progress (1%). A single case of pyometra was detected in ewes (0.5%) whereas remaining disorders were observed in does i.e. pyometra (2.7%) and abortion (2.2%). Total prevalence of reproductive disorders was higher in does (4.9%) than in ewes (0.5%) \( (\text{Chi-square} = 7.38, p = 0.007) \).

Overall, prevalence of small ruminant pregnancy and fetal wastage \( (\text{Chi square} = 5.67, p = 0.017) \) were higher during January 2018 than December 2017 whereas gross reproductive disorders showed limited temporal variation. Body condition was not significantly associated to prevalence of pregnancy \( (\text{Chi square} = 3.77, p = 0.104) \), fetal wastage \( (\text{Chi square} = 4.47, p = 0.107) \) and reproductive disorders \( (\text{Chi square} = 2.9, p = 0.235) \). Species wise, association of study months to prevalence of pregnancy \( (\text{Chi square} = 12.4, p = 0.000) \) and fetal wastage \( (\text{Chi square} = 11.95, p = 0.001) \) were significant in goats. In
sheep, prevalence of pregnancy (Chi square = 8.4, \( p = 0.015 \)) and fetal wastage (Chi square = 8.3, \( p = 0.016 \)) were higher in fat than thin body condition groups (Table 2).

### Table 2. Association Prevalence of pregnancy, fetal wastage, and reproductive disorders with study month and body condition of slaughtered small ruminants

<table>
<thead>
<tr>
<th>Animals</th>
<th>Factors</th>
<th>Categories</th>
<th>Examined (N)</th>
<th>Pregnant N (%)</th>
<th>Fetal Wastage N (%)</th>
<th>Reproductive Disorders N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>Study month</td>
<td>Dec 2017</td>
<td>190</td>
<td>59 (31.1)</td>
<td>64 (33.7)</td>
<td>4 (2.1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Jan 2018</td>
<td>194</td>
<td>83 (42.8) *</td>
<td>89 (45.9) *</td>
<td>6 (3.1)</td>
</tr>
<tr>
<td></td>
<td>Animal Body Condition</td>
<td>Thin</td>
<td>17</td>
<td>3 (17.6)</td>
<td>3 (17.6)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Medium</td>
<td>170</td>
<td>60 (35.3)</td>
<td>64 (37.6)</td>
<td>7 (4.1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fat</td>
<td>197</td>
<td>79 (40.1)</td>
<td>86 (43.7)</td>
<td>3 (1.5)</td>
</tr>
<tr>
<td>Goats</td>
<td>Study Period</td>
<td>Dec 2017</td>
<td>101</td>
<td>22 (21.8)</td>
<td>26 (25.7)</td>
<td>4 (4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Jan 2018</td>
<td>82</td>
<td>38 (46.3) *</td>
<td>42 (51.2) *</td>
<td>5 (6.1)</td>
</tr>
<tr>
<td></td>
<td>Animal Body Condition</td>
<td>Thin</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Medium</td>
<td>77</td>
<td>27 (35.1)</td>
<td>29 (37.7)</td>
<td>6 (7.8)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fat</td>
<td>106</td>
<td>33 (31.1)</td>
<td>39 (36.8)</td>
<td>3 (2.8)</td>
</tr>
<tr>
<td>Sheep</td>
<td>Study Period</td>
<td>Dec 2017</td>
<td>89</td>
<td>37 (41.6)</td>
<td>38 (42.7)</td>
<td>1 (0.9)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Jan 2018</td>
<td>112</td>
<td>45 (40.2)</td>
<td>47 (42)</td>
<td>1 (0.9)</td>
</tr>
<tr>
<td></td>
<td>Animal Body Condition</td>
<td>Thin</td>
<td>17</td>
<td>3 (17.6) b</td>
<td>3 (17.6)b</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Medium</td>
<td>93</td>
<td>33 (35.5)</td>
<td>35 (37.6)</td>
<td>1 (1.1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fat</td>
<td>91</td>
<td>46 (50.5) a</td>
<td>47 (51.6) a</td>
<td>-</td>
</tr>
</tbody>
</table>

Superscript * and ** indicate variations of specific column variable in different categorical factor levels at \( p < 0.05 \) level (2 sided).

After accounting for pregnancy and neonatal losses expected under local conditions, abattoir small ruminant pregnant slaughters incurred net loss of 105 viable offspring (59 sheep and 46 goats) per 384 mature females (201 ewes and 183 doe) slaughtered. This amounted to NEL of 25,415.7 birr (628.95 USD at December 12 2020 exchange rates of 1 USD = 38.82 birr). Projected NEL estimates amounted to 12,243.6 birr (315.4 USD) in goats and 13,172.2 birr (313.55 USD) in sheep. These NEL estimates translate to NER of 66.9 birr (1.72 USD) and 65.5 (1.69 USD) per mature doe and ewe slaughtered at the abattoir, respectively (Table 3).
### Table 3. Abattoir pregnancy/fetal wastage related economic impact calculations and estimates

<table>
<thead>
<tr>
<th>ID</th>
<th>Input Variables</th>
<th>Goats</th>
<th>Sheep</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Females Examined (n)</td>
<td>183</td>
<td>201</td>
</tr>
<tr>
<td>B</td>
<td>Females Pregnant (n)</td>
<td>60</td>
<td>82</td>
</tr>
<tr>
<td>C</td>
<td>Total Fetus in Pregnant Females (n)</td>
<td>68</td>
<td>85</td>
</tr>
<tr>
<td>D</td>
<td>Average Fetus per Pregnant Females (n) = C / B</td>
<td>1.13</td>
<td>1.04</td>
</tr>
<tr>
<td>E</td>
<td>Pregnant Females’ Abortion–stillbirth (n) = ExpASbP (Fentie et al., 2016) x B</td>
<td>10 (16.8% x 60)</td>
<td>12 (14.7% x 82)</td>
</tr>
<tr>
<td>F</td>
<td>Pregnant Females Giving Birth (n) = B - E</td>
<td>50 (60 - 10)</td>
<td>70 (82 - 12)</td>
</tr>
<tr>
<td>G</td>
<td>Live Born Offspring’s (n) = F x D</td>
<td>56 (50 x 1.13)</td>
<td>73 (70 x 1.04)</td>
</tr>
<tr>
<td>H</td>
<td>Pre-mature Offspring Mortality (n) = ExpOMP (Fentie et al., 2016 &amp; CSA 2016/17) x G</td>
<td>10 (18.8% x 57)</td>
<td>14 (18.8% x 73)</td>
</tr>
<tr>
<td>I</td>
<td>Average NMRV (Birr/Animal) (Shapiro et al., 2017)</td>
<td>267.3</td>
<td>223.0</td>
</tr>
<tr>
<td>Ja</td>
<td>NEL (Birr for total females examined) = I x H</td>
<td>12,243.6 (267.3 x 46)</td>
<td>12,172.2 (223 x 55)</td>
</tr>
<tr>
<td>Jb</td>
<td>NEL (USD) = Ja/ 38.82</td>
<td>315.4 (12,179.7/ 38.82)</td>
<td>313.55 (13,128.9/ 38.82)</td>
</tr>
<tr>
<td>Ka</td>
<td>NER (Birr per 1 mature female) = Ja/ A</td>
<td>66.9 (12,179.7/ 183)</td>
<td>65.5 (13,128.9/ 201)</td>
</tr>
<tr>
<td>Kb</td>
<td>NER (USD) = Jb/ A</td>
<td>1.72 (315.4/ 183)</td>
<td>1.69 (313.55/201)</td>
</tr>
</tbody>
</table>
Discussion

Postmortem gross reproductive examination of 384 female small ruminants at Addis Ababa abattoir revealed substantial prevalence of pregnancy (37%) and fetal wastage (39.8%) accompanied by occasional pyometra (1.6%) and imminent abortion (1%). Majority of female small ruminants slaughtered at the abattoir seem to have normal breeding potential as evidenced by rare genital disorders and frequent pregnancy postmortem. In sub-Saharan Africa, pregnant livestock slaughter has been linked to rising unmet domestic demands for meat, farmer economic and husbandry limitations, weak slaughter regulation and other (biological, social and climatic etc.) influences (Abassa, 1995; Tizhe et al., 2010; Atawalna et al., 2013; Mshelia et al., 2015). Ethiopian statistics indicate 1.92 million female small ruminants were slaughtered for domestic consumption in 2017 (CSA, 2017). Previous figure shows a jump of 0.66 million from values a decade back (CSA, 2007) and this was probably driven by growing unmet domestic meat demands (Shapiro et al., 2017). Majority of local small ruminant slaughters occur in unregulated backyards (Legese and Fadiga, 2014) and low-capacity public abattoirs (Mummed and Webb, 2015). Such scenarios reflect risks of broader indiscriminate pregnant livestock slaughter in the country. By contrast, pregnant maternal slaughter in developed regions was often tied to economic reasons like harvesting medicinal pregnancy hormones, salvaging expenses when meat prices drop, etc (Fayemi and Muchenje, 2013).

Pregnant small ruminants slaughtered at Addis Ababa abattoir were between 42 and 109 days of gestation. Majority of pregnant animals were in 2nd trimester (69%) followed by 1st (22.5%) and 3rd (8.5%) trimester stages in decreasing order ($p < 0.05$). Producers appear to verify small ruminant pregnancy by inspecting for gross physical changes like abdominal and mammary enlargement apparent after 100 (often later) days i.e., small percentage of potential pregnant animals targeted for meat. Absence of formidable pregnant small ruminant screening and/or slaughter regulation at abattoir level appears to allow considerable risk of fetal wastage. If done by experienced examiner, abdominal palpation/ballottement for fetal masses can detect small ruminant pregnancy after 70 (preferably 90) days post service. Using real time B mode ultrasonography, it is possible to identify pregnancies as early as 27 (rectal probe) to 40 (trans-abdominal probes) day post-service. The technique offers further benefits of determining litter size as well as age, sex and viability of fetuses. Plasma or milk progesterone levels of 2.5-4 ng/ml 18 – 23 days post-
breeding offers a reliable (80-84 %) indirect indicator of pregnancy whereas 1ng/ml and lower levels at same intervals confirms (100 %) absence of pregnancy (Noakes et al., 2001; Tamassia, 2007; Ptaszynska, 2009).

Postmortem small ruminant pregnancy was currently higher in January (42.8 %) compared to December (31.1 %). Based on pregnancy detection month and stage, conceptions peaked during October and November months. January represents middle of long dry season wherein pasture feed resources is declining as well as a period of high meat demand by Orthodox Christians before stating two months long fast (Seleshe et al., 2014). Small ruminant producers trying to avert risks posed by escalating feed scarcity and attracted by favorable prices may unknowingly sell grossly unapparent pregnant stocks for meat in later month. Conception dates of corresponding gestations coincide with relatively good pasture feed availability at end of major rains reflecting nutrition modulated seasonal fertility fluctuations. Tropical small ruminant flocks exhibit limited breeding seasonality (Ptaszynska, 2009; Petrovic et al., 2012) evidenced by fertile mating peaks around the major and/ or short rains both in Ethiopia and sub-Saharan Africa (Otte and Chilonda, 2002; Abebe, 2008). Brief duration of current abattoir study, could not give full picture of seasonal breeding trends for concerned national small ruminant flocks. A related drawback was inability to evaluate seasonal reproductive trends according to verified geographical origin of study animals.

Currently, abattoir pregnancy and fetal prevalence in ewes (40.8 % and 42.8 %) and doe (32.8 % and 37.2 %) were comparable but twining was lower (p < 0.05) in former (1.5 %) compared to later (4.4 %) species. The two species showed consistent frequency of different gestation stages (2nd > 1st > 3rd trimesters) and overlapping peak fertile mating periods (October and November). Hence conditions influencing reproductive activity and slaughter fate of doe and ewes appear similar. Previous Ethiopian studies had signaled alarming abattoir pregnancy levels including 71.7 % (24 % twins) in central highland sheep (Mukasa-Mugerwa and Tekelye, 2003) as well as 74.4 % (45.7 % twins) in sheep and 47.6 % (60 % twins) in goats at Asella town (Tamirat et al., 2015). Conversely, a recent undergraduate study at Jigjiga abattoir (Yikeber, 2018) reported lower postmortem pregnancy prevalence in goats (22.9 % (1.8 % twins) and sheep (31.5 % (2.7 % twins)). In parallel with Ethiopian trends, widely varying abattoir small ruminant pregnancy and fetal wastage levels have been reported from other African countries. Main examples include 38.6 to 57.7 % (2.2 % multiple fetuses) in sheep and 40 to 51.8 % (3.5 - 33 % multiple
fetuses) in goats from Tanzania (Swai et al., 2015; Kashoma and Melkiory, 2017; Kilumbi and Nonga, 2018); 15.7 to 47.7 % (25.1 % multiple fetuses) in sheep and 19 to 59 % (17.3 - 66.3 % multiple fetuses) in goats from Nigeria (Addass et al., 2010; Tizhe et al., 2010; Mshelia et al., 2015; Okorie-Kanu et al., 2018); and 50.6 % (50.4 % multiple fetuses) in sheep and 20.4 % (77.35 % multiple fetuses) in goats from Ghana (Tasiame et al., 2016). Most Ethiopian and African studies had observed higher fetal wastage in 1st and/or 2nd trimesters suggesting drawbacks of gross physical pregnancy screening approaches adopted across the region.

Discrepancy of abattoir fetal wastage across and within geographic regions has been attributed to variable climatic, husbandry and genetic influences on fertility (Addass et al., 2010; Tizhe et al., 2010; Fayemi and Muchenje, 2013). Ethiopian studies reflect higher risk of pregnant slaughter in sheep but higher frequency of twining in goats with effect of evening out total species fetal wastage volumes. Fetal wastage in both species also tended to be higher in highland compared to lowland abattoirs. Ethiopian highland sheep tend to have short heavy body frame with coarse wavy wool that conceals abdomen whereas local goats often show lean body frames with short smooth hair coats (FARM Africa, 1996; Awgichew and Abegaz, 2008). Such differences could render gross detection of late pregnancies more difficult in ewes compared to doe resulting in parallel pregnant slaughter discrepancies. Greater pastoralist milk supply function of goats (Awgichew and Abegaz, 2008; Legesse and Fadiga, 2014) could further discourage slaughter of goats with suspected pregnancy. Relatively better pasture and crop byproduct availability in highland compared to lowland areas (Gizaw et al., 2010; Sheriff and Alemayehu, 2018) could reflect fertility effects corresponding to abattoir pregnancy variations. Twining rate of indigenous sheep and goat’s shows wide variability (2 – 51 %) reflecting genetic and nutritional influences on ovulation rates (Sheriff and Alemayehu, 2018). Broader feeding range of goats compared to sheep may allow higher ovulation rates in former species under pasture deficient conditions. Further, Somali and Borana pastoralists were suggested to deliberately cull twin bearing doe for slaughter so as to improve kid survival and family milk supply (FARM-Africa, 1996).

Economic cost of abattoir small ruminant fetal wastage was currently estimated employing species-specific approach that accounted for average expected pregnancy and offspring losses as well as net financial values of national flocks. Gross fetal wastage levels observed at Addis Ababa abattoir were pro-
jected to result in net loss of 105 potential viable offspring’s (46 goat and 59 sheep) amounting to NEL 313.55 USD in sheep and 315.4 USD in goats. Later estimates reflect NER of around 1.7 USD attributable to fetal wastage for each mature doe and ewe slaughtered at the abattoir. If 50 % of the 36,000 sheep and 18,000 goats reported to be annually slaughtered at the abattoir (Assefa et al., 2017) were in active breeding state, current NER estimates would result in NEL of 45,900 USD per year. If same NER level was extended to half of annual domestic female goat (875, 406) and sheep (1,049, 052) slaughters (CSA, 2017), Ethiopia stands to lose around 3.3 million USD due to abattoir fetal wastage. Previous studies had reported higher abattoir small ruminant fetal wastage related to annual economic losses of 158,560.0 USD in Ethiopia (Tamirat et al., 2015) and 464,940.0 - 774,900.0 USD in Tanzania (Kashoma and Melkiory, 2017). Larger annual female slaughter volumes; lower expected pregnancy (14 %) and neonatal (19 %) loss risks; and higher gross small ruminant market values used towards later projections could explain corresponding inflated projections. Meanwhile, annual economic losses calculated based on gross market values of small ruminant newborns (15 – 20 USD) was estimated between 228, 240.0 and 380,400.0 USD at two Tanzanian abattoirs (Kilumbi and Nonga, 2018) and around 46,480 USD in Nigerian goats (Okorie-Kanu et al., 2018). Apart from considering larger annual female slaughter volumes and net animal financial values, later studies ignored risks of heavy pre-weaning mortality expected under tropical small ruminant farming systems (Abassa, 1995; Otte and Chilonda, 2002; Fentie et al., 2016).

Causes of reproductive failure (infertility) in small ruminants are diverse involving failure to mate; failure to conceive; embryo or fetal loss; and neonatal mortality (Ptaszynska, 2009). Research on epidemiology of small ruminant infertility is patchy in Ethiopia (Abebe, 2008). This study noted higher prevalence of imminent abortion (2.2 %) and pyometra (2.7 %) in goats as compared to only 0.5 % pyometra in ewes. Abortion is a major cause of small ruminant infertility associated to specific or non-specific genital infections, environmental stress and/ or maternal factors (Ptaszynska, 2009; Pugh, 2016). Previous small ruminant abortion prevalence estimates in Ethiopia varied from 2.4 to 45.4 % (Abassa, 1995; Fentie et al., 2016). The etiological and predisposing factors behind such discrepancy are not well known. Non specific genital infections have been given limited attention in small ruminants compared to larger livestock. Yet, predisposing risk factors such as abortion, genital prolapse, dystocia and placenta retention are common in small ruminant suggesting potential importance of non-specific genital infections in these species.
Conclusions

Despite limited temporal coverage and sample size, this study tried to offer useful insights on epidemiology and financial impacts of pregnant doe and ewe slaughtered (fetal wastage) at Addis Ababa abattoir. Regular slaughter of mature female animals coupled with lack of robust ante-mortem pregnancy screening system appears to contribute to substantial fetal wastage in physically inconspicuous gestational stages. This trend could undermine sustainable livestock meat productivity and consumption. Hence, further studies are needed to deepen knowledge on epidemiology and impacts of abattoir pregnancy/fetal wastage at broader scale including other food animal species. Responsible bodies need to pay attention to this wasteful practice and enact proper regulations by evaluating feasibility of accurate ante-mortem pregnancy screening primarily by ultrasound scanning systems.

Conflict of interests

The authors have not declared any competing of interests

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