FORAGING AND BODY CONDITION CHARACTERIZATION OF GOATS IN NORTHWESTERN INDIA

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ABSTRACT

Our objective was to characterize feeding practices and nutritional status of goats in the Jhadol block, Udaipur district (Rajasthan) in northwestern India. Goat owners (n=64) were interviewed in 10 villages of Jhadol block. The questionnaire targeted aspects of the livestock system including socio-economic characteristics, livestock management, goat feeding and physical assessment of goat condition, and was broken into general household data, goat husbandry practices, goat diet composition, feeding habits, feed shortage mitigation, crop residue use and lactation. Local inhabitants relied heavily on their own land (77%) for subsistence and many depended on income as wage labourers (38%). Households owned between one and 22 goats, with an average of 6.59 goats. Goat health was assessed with body condition scoring, which was significantly correlated with geographic cluster (P=0.0049), household forage cultivation (P=0.0238) and rainy season lopping of tree branches for goat feed (P=0.0275). Goat management practices were defined by the total number of seasons that households took goats foraging away from home. Seasons foraged correlated with geographic cluster (P=0.0004), goat herd size (P=0.0055) and total number of other livestock owned (P=0.013). These aspects of the semi-intensive goat system in Udaipur district improve understanding of household characteristics and practices impacting nutritional management and goat condition. Information presented here advances knowledge of goat farming systems in rural northwestern India and can direct future goat nutrition research initiatives.

Key words: Feeding, Goat, Semi-intensive, Smallholder farmer
Fodder scarcity is a major obstacle for Indian livestock production (Roy and Singh, 2008). Physiological functions suffer (e.g., onset of puberty, growth, fertility, milk production, disease resistance, and absorption of essential nutrients) when energy supply is inadequate (Kearl, 1982). Devendra’s (2013) analysis of successful and unsuccessful goat development projects identified feeding and nutrition as major constraints to animal productivity. A deficit of 67% in green fodder, 32% in dry fodder and 22% in concentrates is expected for Indian livestock in 2015 (Roy and Singh, 2008). Wise use of available fodder and feed resources is required to sustain India’s growing livestock population (Roy and Singh, 2008).

Consequently, the objectives of this study were to characterize household goat feeding practices and assess goat nutrition and health with body condition scoring. We highlight opportunities to improve goat nutrition and health in the Jhadol block of Udaipur district (Rajasthan). Our assessment is best viewed as a first-stage characterization study that can improve understanding of goat management, including nutritional opportunities and constraints to goat production in the study area, and help identify key areas for subsequent research.

MATERIALS AND METHODS

Research was conducted in western Udaipur district (Rajasthan), India. Jhadol block, the study’s central research base, is located 60 km southwest of Udaipur city. Udaipur experiences three main seasons: rainy (July to September), winter (October to mid-March), and summer (mid-March to June). We focused on four clusters (Ogna, Jhadol, Kantharia and Baghpura) in Jhadol block. All survey respondents were considered below the poverty line according to Rajasthan State government household census and scoring system. Goat keepers operated in a semi-intensive system with both free-browsing and stall-feeding, which depended on season and biomass availability. Most goat owners had minimal knowledge of best management practices (e.g., planned breeding, deworming and vaccinations) (ILRI, 2012a).

Interviews (n=64) were completed with farm families in August and September 2013. Interviews were supplemented by researcher observations, goat body condition scoring, and animal tracking to foraging areas. Our questionnaire consisted of 49 questions addressing socioeconomic status, goat husbandry practices, goat diets, feeding habits, feed shortage mitigation, crop residue use and lactation.

Interviewed farmers were randomly selected within villages to generate a diverse, geographically representative sample from clusters in Jhadol block. Two villages were randomly selected in three clusters, while four villages were selected in a fourth cluster (Ogna) because Ogna village populations were low. Eight households were randomly selected in each village in the first three clusters, and four participants were selected in each Ogna village. Thus, 16 households were interviewed in each cluster for a total sample population of 64 participants. Household interview duration was approximately one hour. Missing and abnormal data were addressed with follow-up discussions in person or by phone. Available goats in surveyed households (n=419) were individually photographed and body condition scored by applying a 9-point palpation and observation-based scale from 1 to 5 with 0.5-point increments, according to Langston University guidelines (Detweiler et al., 2008).

Statistical analysis was executed in JMP 9.0.2 (SAS Institute). Thirty-one variables from the total survey were used in statistical data analysis (Tables 1 and 2). As with all recall surveys, responses represent farmer perceptions about biological and economic realities (excluding researcher-measured body condition scores). Selected variables with low variation and those that were not answered consistently were removed. Body condition score and number of seasons foraged, were targeted with ANOVA statistical analyses to assess goat health and household goat foraging decisions. Significant mean differences were declared at P≤ 0.05 with Tukey’s adjustment for multiple comparisons. Retrospective power of tests was calculated for fixed effects models. Body condition score was analyzed in a linear mixed model with cluster as a fixed effect and household as a random effect to determine significantly different geographic regions.
RESULTS AND DISCUSSION

Local inhabitants were heavily reliant on their own land for subsistence, and many inhabitants depended on income as wage labourers (38%). Majority of participants (54%) identified goats as their most important livestock asset. Popular reasons for owning goats as a percentage of total respondents were live animal sales (100%), sales in case of emergency (100%), milk consumption (98%) and manure as a soil amendment (95%). Less frequent reasons for owning goats were sacrifice (28%) and meat consumption (9%). Goat milk was primarily used for home consumption or left for goat kid consumption. A few respondents (3%) reported goat milk sales. Goat milk production estimates ranged from 488 g/d during peak lactation to 165 g/d in late lactation.

Elder women (grandmothers no longer rearing their own children) acted as primary goat caretakers in most households (73%). Other primary caretakers reported by respondents included elder males (14%) and female children (8%). Adult females, adult males, and male children were the main caretakers in 5% of households. Caretakers fed grasses and shrubs on the ground (50%) or by hanging (50%). A quarter of respondents practiced drying leaves for alternative livestock feed during times of scarcity. Descriptive statistics for other variables of interest provide further background information on household, goat, and goat management characteristics (Table 1 and 2).

Table 1. Descriptive statistics for continuous survey variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>Description</th>
<th>n</th>
<th>Mean</th>
<th>SEM</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body condition score</td>
<td>Body condition based on Langston University 5-point scale (Detweiler et al., 2008)</td>
<td>419</td>
<td>1.78</td>
<td>0.0176</td>
<td>1</td>
<td>2.5</td>
</tr>
<tr>
<td>Total goats owned</td>
<td>Number of goats owned by household</td>
<td>64</td>
<td>6.59</td>
<td>0.515</td>
<td>1</td>
<td>22</td>
</tr>
<tr>
<td>Annual hours walked</td>
<td>Estimated hours walked per season totaled</td>
<td>64</td>
<td>2029</td>
<td>103</td>
<td>0</td>
<td>3650</td>
</tr>
<tr>
<td>Total animals owned</td>
<td>Total animals owned by household</td>
<td>64</td>
<td>11.6</td>
<td>0.765</td>
<td>3</td>
<td>34</td>
</tr>
<tr>
<td>Adult women in household</td>
<td>Number of adult women in surveyed household</td>
<td>64</td>
<td>1.72</td>
<td>0.116</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Adult men in household</td>
<td>Number of adult men in surveyed household</td>
<td>64</td>
<td>1.63</td>
<td>0.122</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Total members in household</td>
<td>Total people in surveyed household</td>
<td>64</td>
<td>6.73</td>
<td>0.301</td>
<td>2</td>
<td>13</td>
</tr>
<tr>
<td>Land</td>
<td>Amount of land (ha)</td>
<td>64</td>
<td>0.512</td>
<td>0.031</td>
<td>0.08</td>
<td>1.12</td>
</tr>
<tr>
<td>Education</td>
<td>Household's highest level of education (years studied)</td>
<td>64</td>
<td>7.03</td>
<td>0.469</td>
<td>0</td>
<td>13</td>
</tr>
</tbody>
</table>

Table 2. Descriptive statistics for categorical survey variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>n</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household</td>
<td>Individual household surveyed</td>
<td>64</td>
<td>-</td>
</tr>
<tr>
<td>Village</td>
<td>Villages where surveyed</td>
<td>10</td>
<td>-</td>
</tr>
<tr>
<td>Cluster</td>
<td>Geographic area containing villages</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>Foraged during</td>
<td>Number of participants that took goats</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rainy season</td>
<td>foraging in each season</td>
<td>45</td>
<td>70.3</td>
</tr>
<tr>
<td>Winter season</td>
<td></td>
<td>52</td>
<td>81.3</td>
</tr>
<tr>
<td>Summer season</td>
<td></td>
<td>61</td>
<td>95.3</td>
</tr>
<tr>
<td>Number of seasons foraged</td>
<td>Number of seasons household took goats foraging outside of home</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-1</td>
<td></td>
<td>10</td>
<td>15.6</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>13</td>
<td>20.3</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>41</td>
<td>64.1</td>
</tr>
<tr>
<td>Lopped rainy season</td>
<td>If household lopped branches in rainy season</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td>14</td>
<td>21.9</td>
</tr>
<tr>
<td>No</td>
<td></td>
<td>50</td>
<td>78.1</td>
</tr>
<tr>
<td>Cultivated forages</td>
<td>If household cultivated forages</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td>43</td>
<td>67.2</td>
</tr>
<tr>
<td>No</td>
<td></td>
<td>21</td>
<td>32.8</td>
</tr>
<tr>
<td>Electricity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Had electricity</td>
<td></td>
<td>42</td>
<td>65.6</td>
</tr>
<tr>
<td>Did not have electricity</td>
<td></td>
<td>22</td>
<td>34.4</td>
</tr>
</tbody>
</table>
Respondents reported lopping 46 different tree species. The most common species reported were *Ziziphus mauritiana* Lam (61% of respondents), *Anogeissus latifolia* (Roxb. ex DC.) Wallich ex Bedome (39%), *Albizia lebbeck* Benth (23%), *Acacia leucophloea* (Roxb.) Wild (17%), *Adina cordifolia* (Roxb.) Hook f. (13%) and *Anogeissus sericea* Brandis (11%). Most lopping was conducted in the forest, but some lopping of cultivated fodder trees was also reported. Fodder trees were grown by 42% of respondents, with the following popular species: *Ziziphus mauritiana* Lam (34%), *Albizia lebbeck* Benth (6%) and *Leucaena leucocephala* (Lam.) de Wit (6%). Majority of households cultivated fodder (67.2%), and 50% of households that cultivated fodder grew multiple species. Grass and/or legume forages were cultivated by 45% of total households. Commonly cultivated grass and legume species were *Medicago sativa* L. (30%) and *Echinochloa colonum* L. (16%). Average land size allocated for tree and forage cultivation was 0.067 ha. The household decision to cultivate fodder was not significantly correlated with land (P= 0.6187), total goats owned (P= 0.6765) or education (P= 0.5427).

Several results from our study are comparable to findings in a 2012-2013 International Livestock Research Institute (ILRI) baseline study in the same region (ILRI, 2012a). Popularly lopped trees in ILRI's baseline study were *Ziziphus mauritiana*, *Acacia nilotica* (L.) Del, *Acacia leucophloea* and *Azadiracta indica* A. Juss (ILRI, 2012a). Results of our study included additional trees such as *Anogeissus latifolia*, *Albizia lebbeck*, *Adina cordifolia* and *Anogeissus sericea*. These plant species may vary depending on the diverse ecology near specific villages in Udaipur district. For example, commonly fed plants in Ranpur village differed from plants in Barlipara village, though these villages were only 50 km apart.

Seeds and saplings of *Sesbania sesban* (L.) Merr and *Leucaena leucocephala* (Lam) de Wit were distributed to farmers locally based on their highly palatable characteristics and the ability to combine with roughages in goat rations (Orwa et al., 2009b, c). *Leucaena leucocephala* nutritive value has been analyzed in India at 22% crude protein, 56% neutral detergent fibre and 37% acid detergent fibre and is considered a nutritious livestock feed (Bakshi and Wadhwa, 2004). Local village representatives voiced support for promotion of *Ziziphus mauritiana* (Basantilal Ahari, personal communication, August 25, 2013), because it is a local plant species. *Sesbania leucaena* nutritive value was analyzed at 16% crude protein, 60% neutral detergent fibre and 44% acid detergent fibre (Bakshi and Wadhwa, 2004), demonstrating nutritive potential as tropical fodder. *Acacia leucophloea* (is an important fodder species in the region, but green pods contains high hydrocyanic acid that can poison goats when consumed in large quantities (Orwa et al., 2009a). Project participants voiced concerns and enlisted advice for cyanide poisoning of their goats from pods (ILRI, 2012b). Consideration of farmer adoption potential for agroforestry tree species is important to development projects. Our field observations suggest that adoption of local tree species could be higher than introduced species due to management and cultivation familiarity, and that some of these species have high nutritive value potential.

Several results from our study are comparable to findings in a 2012-2013 International Livestock Research Institute (ILRI) baseline study in the same region (ILRI, 2012a). Popularly lopped trees in ILRI's baseline study were *Ziziphus mauritiana*, *Acacia nilotica* (L.) Del, *Acacia leucophloea* and *Azadiracta indica* A. Juss (ILRI, 2012a). Results of our study included additional trees such as *Anogeissus latifolia*, *Albizia lebbeck*, *Adina cordifolia* and *Anogeissus sericea*. These plant species may vary depending on the diverse ecology near specific villages in Udaipur district. For example, commonly fed plants in Ranpur village differed from plants in Barlipara village, though these villages were only 50 km apart.

### Table 3. Cluster-wise body condition score of goats

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Least squares mean</th>
<th>SEM</th>
<th>Tukey’s HSD</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ognna</td>
<td>1.94</td>
<td>0.00582</td>
<td>a</td>
<td>0.0049</td>
</tr>
<tr>
<td>Jhadol</td>
<td>1.76</td>
<td>0.00617</td>
<td>a, b</td>
<td></td>
</tr>
<tr>
<td>Kantharia</td>
<td>1.72</td>
<td>0.00472</td>
<td>b</td>
<td></td>
</tr>
<tr>
<td>Baghpura</td>
<td>1.67</td>
<td>0.00494</td>
<td>b</td>
<td></td>
</tr>
</tbody>
</table>

*Household as random effect; Tukey’s HSD levels not connected by same letter are significantly different
Goat foraging and body condition

Goat body condition score was significantly higher for households that cultivated forages (1.83) than households that did not cultivate forages (1.69), because potentially more forage of higher nutritive value was fed. Potential for higher dry matter intake and higher digestibility could contribute to observed body condition score differences (Table 4). Households supplemented goat diets with forages near the household when forages were cultivated. Thus, adoption of fodder cultivation could improve overall goat nutrition and health. Households that did not cultivate forages would be more susceptible to forage availability in common property resources, which varies with rainfall and livestock stocking rates from common land users.

Body condition score was also significantly higher for respondents that lopped branches in the rainy season (1.9) than respondents that did not lop branches (1.74). Body condition score was not affected by annual hours walked or annual km walked (Table 4). Higher dry matter intake relative to more stationary goats may have offset energy expenditures from walking. According to calculations made with the small ruminant nutrition system (Tedeschi et al., 2010) based on a diet of whole barley, corn cobs, long alfalfa hay and an over-grazed pasture mixture, each additional kilometer walked per day increases a goat’s metabolizable energy requirement by 0.033 Mcal/d, and each additional 100 m in elevation change increases the goat’s metabolizable energy requirement by 0.026 Mcal/d. Thus, a goat that walks 10 km with an altitude change of 200 m would have a metabolizable energy requirement 0.382 Mcal/d higher than a stall-fed animal. Households with access to additional fresh biomass from cultivated forages can offer more feed at home while reducing energy expenditures relative to animals that spend more time foraging. Time spent foraging on common lands may increase household risk because poor households are increasingly losing access to common property resources (Jodha, 1985; Beck and Nesmith, 2001). Livestock fed near the household using cultivated forages could help mitigate fluctuations in biomass availability in common property resources. Research targeting the impact of these management changes on sustainability of the local crop-livestock system could help improve goat health, goat nutrition, and understanding about household decision tradeoffs between forage cultivation and cash or food crop cultivation on limited landholdings.

Table 4. Mixed model comparisons for body condition score (Each line represents a single model)

<table>
<thead>
<tr>
<th>Fixed effect</th>
<th>Estimate</th>
<th>SEM</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultivated forages (reference group=yes)</td>
<td>-0.069</td>
<td>0.00374</td>
<td>0.0238</td>
</tr>
<tr>
<td>Lopped rainy season (reference group=yes)</td>
<td>-0.078</td>
<td>0.00429</td>
<td>0.0275</td>
</tr>
<tr>
<td>Adult women in household</td>
<td>0.066</td>
<td>0.00386</td>
<td>0.0369</td>
</tr>
<tr>
<td>Adult men in household</td>
<td>0.589</td>
<td>0.0381</td>
<td>0.0463</td>
</tr>
<tr>
<td>Annual hours walked</td>
<td>2.25E-5</td>
<td>0.00</td>
<td>0.5567</td>
</tr>
<tr>
<td>Annual km walked</td>
<td>-5.87E-6</td>
<td>0.00</td>
<td>0.7739</td>
</tr>
</tbody>
</table>

- Household as random effect; - Effect coding used for categorical variables

Plate 1. Body condition score examples. Left goat body condition score is 1 and right goat body condition score is 2
Number of seasons foraged was most significantly impacted by cluster, total goats owned and total animals owned (Tables 5 and 6). According to ILRI's baseline survey (ILRI, 2012a), participants considered the labour allocation required for goat foraging to be unproductive for small herd sizes. This finding is consistent with our results – households with small herds reported goat herding in fewer seasons. The ILRI report indicated that 54.4% of survey respondents took goats foraging in the rainy season, 56% in winter, and 73.2% during the summer. Reported taking goats foraging in our study was 70% in rainy, 81.3% in winter and 95% in summer season. Thus, a higher proportion of households in our study (relative to ILRI's) engaged in goat foraging activities throughout the year, although differences among seasons were comparable to our study. Different villages surveyed in ILRI's study may account for differences, in addition to possible differences in questionnaires and survey question delivery.

Table 5. Bivariate models with number of seasons foraged as predictor (Each line represents a single model)

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>0 or 1 season (n=10)</th>
<th>2 seasons (n=13)</th>
<th>3 seasons (n=41)</th>
<th>Power</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SEM</td>
<td>Mean</td>
<td>SEM</td>
<td>Mean</td>
</tr>
<tr>
<td>Total animals owned</td>
<td>10.7</td>
<td>0.579</td>
<td>7.62</td>
<td>0.445</td>
<td>13.2</td>
</tr>
<tr>
<td>Total goats owned</td>
<td>4.3</td>
<td>0.385</td>
<td>4.54</td>
<td>0.296</td>
<td>7.81</td>
</tr>
<tr>
<td>Adult women in household</td>
<td>1.3</td>
<td>0.0904</td>
<td>1.39</td>
<td>0.0696</td>
<td>1.93</td>
</tr>
</tbody>
</table>

Table 6. Number of seasons foraged by cluster

<table>
<thead>
<tr>
<th>Cluster</th>
<th>0 or 1 season</th>
<th>2 seasons</th>
<th>3 seasons</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ógna</td>
<td>1</td>
<td>1</td>
<td>14</td>
<td>0.0004</td>
</tr>
<tr>
<td>Jhadol</td>
<td>0</td>
<td>3</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Kantharia</td>
<td>3</td>
<td>2</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Baghpura</td>
<td>6</td>
<td>7</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

Building awareness of goat ownership potential to generate income and improve food security for households could stimulate investment in improved goat productivity measures in Jhadol block and similar semi-arid zones. Households generally view goats as a source of supplementary income. Consequently, investment in goat nutrition is not a major household priority. Increased household awareness about the benefits of investing in goat production (e.g., increased productivity and profits), could increase time and resources invested in goats. Further investigation is needed to quantify goat dry matter intake, incorporating a more complete understanding of ration components (e.g., botanical names and nutritive value data for plants fed to goats). This information would facilitate empirical analysis of nutritional deficiencies and opportunities in Jhadol block, as well as in other similarly managed extensive and semi-intensive systems in India. Vegetation was plentiful during the time of this study (rainy season) and findings would likely differ during other seasons when fresh forage and fodder shortfalls exist. Evaluation of goat nutritional constraints should include an investigation of dry season goat feeding and management strategies. Respondents contributed information for dry periods. However, survey application timing may have impacted outcomes.

This research complements previous studies demonstrating the undernourished status of India's livestock in rural areas due to animal feed shortages (Roy and Singh, 2008). India's widespread scarcity of livestock fodder may require families to expand use of personal land for fodder cultivation instead of relying on common property resources. Small landholdings challenge household ability to use available land for forage cultivation, because land is already designated for cash and household consumption crops. Further research in Udaipur district and similar regions could assess the impact of increased fodder cultivation on system sustainability. Government policies such as subsidies or other incentives may be warranted to promote fodder cultivation to address India's national fodder scarcity dilemma (Conroy and Lobo, 2002). An ex ante study of the impact of fodder subsidies on fodder scarcity and smallholder livelihoods, including consideration of potential unintended consequences should be considered prior to implementation. Crop residues already form the foundation of ruminant diets in India, and efforts to improve digestibility and access to high quality crop residues will help fill feed gaps for
undernourished Indian livestock, including goats. Research testing the impact of crop residue utilization for goat diet supplementation during periods of fodder and forage scarcity will demonstrate benefits and pitfalls of this strategy for smallholders.

Present and future looming shortages of Indian livestock fodder highlight the importance of making wise use of available feed resources and seeking alternative energy sources for animal production. Characterization of goat foraging and body condition in Jhadol block, Udaipur district provides a snapshot of one fodder situation facing livestock in a semi-arid, non-irrigated region in India. As pressure increases for livestock feed resources from population growth and competing land use, increased goat ownership and more intensive management could help smallholders adapt to changing conditions, including land and labor constraints. Further research is needed to address fodder constraints and opportunities, because already disadvantaged Indian families will probably be most affected by growing national fodder shortfalls.

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