Challenges and opportunities for agro-pastoral livestock smallholders in Mali

Andrés F. Cibils, DeAnn McGrew, Bara Kassambara, Konimba Bengaly, Bourama Sissoko and Ram N. Acharya

Abstract: *This paper reports on an in-depth assessment of smallholder livestock production in rainfed agro-pastoral communities of Mali through an analysis of data from 36 case studies. Approximately 1,108 farmers were involved, with two-thirds of the case studies focusing on ruminant production and the remainder dealing with cooperative capacity building. Feeding and forage-related needs were the most frequently assessed in the case studies involving smallholders raising small ruminants or cattle, whereas organization-related needs were the most frequently assessed in those involving smallholder livestock cooperatives. Meeting the feed and forage requirements of small ruminants and cattle is the most urgent need for livestock smallholders, but addressing this challenge will be difficult without concurrent control of the breeding season and common diseases as well as implementation of appropriate methods to track and cull unproductive animals. Empowerment of grass-roots organizations, particularly women's cooperatives, through literacy programmes and effective extension outreach could have significant impacts on the improvement of smallholder livestock enterprises.*

Keywords: *animal feeding; animal health; animal reproduction; cooperative organization*

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Livestock products rank among the top 10 key agricultural commodities produced in Mali, with their combined value accounting for approximately half of the country's agricultural gross domestic product (GDP) (FAO, 2014). Despite its high potential, Mali's current national accounting system undervalues the contribution of livestock to the economy, making it a less attractive investment option for both public and private investors than other alternatives (Alary *et al*, 2011; Amadou *et al*, 2012). As a result, the livestock industry has received limited financing from both sectors and its average productivity is low in terms of milk and meat production per cow (Coulibaly and Nialibouly, 1998; Amadou *et al*, 2012). Thus, exponential growth of livestock inventories over the past two decades (Figure 1) has not been mirrored by increases in productivity indicators (FAO, 2014). Offtake rates and milk production per animal have remained fairly flat (Figure 1), lagging behind those of other developing countries (FAO, 2014) and causing domestic demand for animal products (especially milk) to remain unmet (Pica-Ciamarra *et al*, 2007; FAO, 2014). Demand for meat and milk in Sub-Saharan Africa is predicted to grow steadily

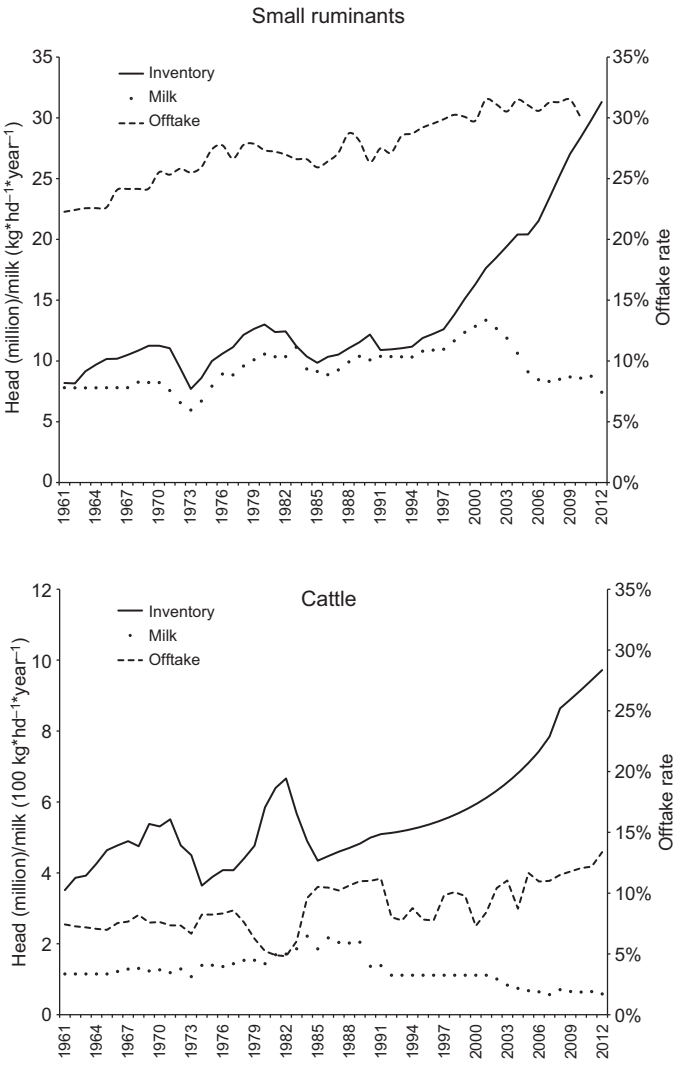

Figure 1. Long-term (1961–2012) trends in small ruminant and cattle inventory, milk production and offtake rate for Mali, according to FAOSTAT.
Note: Offtake rate is calculated as a percentage of slaughtered animals relative to the total inventory. Milk production rate is calculated as total milk production (tons) divided by total milk animals (head).

in the coming decades (Pica-Ciamarra *et al*, 2007). Therefore productivity of Malian herds will need to increase dramatically to prevent the gap between demand and supply of animal protein from widening, and to relieve the growing pressure exerted on pastoral lands by a growing number of less mobile livestock herds (Turner, 1993; Turner *et al*, 2005; Pica-Ciamarra *et al*, 2007; Roncoli *et al*, 2007).

As in most of Sub-Saharan Africa (Thornton *et al*, 2003), livestock in Mali play a critical role in alleviating poverty and reducing the vulnerability of rural communities (Alary *et al*, 2011). In addition to being a tradable commodity, livestock serve as a preferred wealth store, not only among farmers and herders but also among urban dwellers (Roncoli *et al*, 2007; Turner, 2009). This form of investment is selected due to its 'lower perishability (compared to grain stores and paper money), limited liquidity (protection from requests by others), and ability to grow over time' (Turner, 2009, p 749). Livestock serve as a source of cash in hand to cover household emergency expenses (Alary *et al*, 2011), and over the longer term provide an insurance to mitigate the risk of catastrophic crop losses during droughts (Turner *et al*, 2014). In addition to these multiple values of livestock, factors such as the risk of theft and losses during short- or long-range transhumance (Turner *et al*, 2014) as well as market prices based on appearance rather than animal weights (Alary *et al*, 2011) partially explain the propensity of Mali's livestock sector to prioritize livestock numbers over herd productivity (Figure 1). However, recent studies have shown that an increase in livestock productivity could substantially enhance farm income, lift more than one billion people out of poverty and meet the rising global demand for animal products (McDermott *et al*, 2010; Amadou *et al*, 2012).

Livestock production systems vary widely across Mali, ranging from transhumant and nomadic to rural or peri-urban, semi-sedentary herds (Amanor, 1995). This paper focuses on rainfed agro-pastoral systems where (i) livestock raising is a subsidiary activity (relative to crop farming), (ii) herds have moderate levels of mobility (Turner *et al*, 2014) and (iii) livestock provide 10 to 50% of household income (Traore and Wilson, 1988). The most comprehensive characterization of these systems was conducted by the International Livestock Centre for Africa (ILCA, now the International Livestock Research Institute, ILRI) in the area of Niono in central Mali during the late 1970s and early 1980s (Kolff and Wilson, 1985; Wilson, 1985, 1987; Wilson and Sayers, 1987; Wilson and Durkin, 1988; Wilson and Traoré, 1988). Overall, the results of this project reported a generalized lack of control of the breeding season, high levels of abortions and stillbirths and small litter sizes in sheep and goats, delayed puberty and long intervals between parturitions in cattle, high pre-weaning mortality rates in sheep and cattle, relatively high adult mortality rates in sheep and goats, and low offtake rates for all livestock species. Most of these deficiencies, which in many cases persist today, were largely attributed to herd malnutrition (Traore and Wilson, 1988).

Livestock-related studies conducted in Mali since the ILCA project have focused primarily on socio-ecological aspects of pastoral systems (Turner, 1993; de Bruijn and van Dijk, 1999, 2003; Turner, 1999a, 1999b, 2009; Behnke *et al*, 2010; Brottem *et al*, 2014; Turner *et al*, 2014) or, in a few cases, on irrigated agro-pastoral smallholder livestock raising (Agyemang *et al*, 2007; Doumbia *et al*, 2012). Our key objective was to develop an in-depth assessment of the current state of smallholder livestock production in rainfed agro-pastoral communities of Mali by conducting a meta-analysis of 36 case studies carried out by expert volunteers. A secondary objective was to develop a catalogue of needs of smallholders within these systems to provide criteria to inform future intervention programmes in Mali.

Methods

Data collection

Our data were collected by expert volunteers who conducted on-site work with smallholder livestock producers

in villages of the central, western and southern regions of Mali between 2009 and 2013. Volunteer work was coordinated by Winrock International (www.winrock.org) and Agricultural Cooperative Development International/ Volunteers in Overseas Cooperative Assistance (ACDI/ VOCA, www.acdivoca.org) and funded by the United States Agency for International Development (USAID) via the John Ogonowski and Doug Bereuter Farmer-to-Farmer (F2F) Program and the Mali Agriculture Value Enhancement Network (MAVEN) Program (www.usaid.gov). Documentation associated with each volunteer assignment typically consisted of (i) a scope of work (SOW) developed by Winrock Mali staff in consultation with the farmer organization seeking help (host) and a partner governmental (GO) or non-governmental organization (NGO), (ii) an end of assignment (EOA) report produced by each expert volunteer, often in collaboration with Winrock Mali staff, and (iii) an impact assessment (IA) conducted by Winrock approximately six months after completion of an assignment.

Host selection was conducted by Winrock Mali staff with input from local GOs and/or NGOs who provided additional information regarding the needs and organizational profile of the farmer associations seeking help. All hosts in this study were cooperatives or associations of smallholder producers, often women's cooperatives, seeking help to solve specific production-related or organization-related challenges. Volunteers with expertise best matching the needs of the host were selected by Winrock or ACDI/VOCA. Most expert volunteers resided in the USA and were affiliated with higher education institutions or NGOs, or were farmers/ranchers, private consultants or individuals who had retired from careers in agriculture. Each assignment typically consisted of an initial meeting with Winrock Mali staff to discuss SOW specifics, followed by an on-site assessment phase with direct input from interested farmers. In all cases, Winrock Mali technical outreach coordinators served as interpreters, bridging language and cultural gaps and allowing effective communication between volunteers and their host. Based on information gathered during the initial needs assessment, volunteers usually delivered a series of training sessions that concluded with a meeting during which the host was provided with a set of recommendations for improvement.

Prior to leaving Mali, each volunteer developed an EOA report with descriptions of their assessment of the host organization's needs, limitations and opportunities. This always included a record of the number of farmers involved in the assignment and a list of recommendations for improvement. Thus, EOA reports contained a wealth of socio-agricultural insights about the host organization (smallholder farmers) and a list of specific suggestions that were a direct reflection of the needs of a host as perceived by the expert volunteer. Approximately six months after assignment completion, Winrock conducted an impact assessment, which consisted of meetings with the host to determine the degree to which volunteer recommendations had been adopted and to gauge the impact of the volunteer assignment by calculating a number of quantitative indicators. These often included important qualitative data including observations made by the staff conducting the interview and/or quotations of interviewee impressions regarding the applicability of a volunteer's recommendations and factors limiting their adoption.

Data analysis

We analysed reports associated with 36 case studies conducted by 27 experts who worked with farming communities in Ségou, Kayes, Koulikoro and Sikasso (Table 1). Approximately 1,108 farmers were involved in assessment and training activities associated with these 36 case studies (Table 1). Close to two-thirds of all the case studies analysed focused on ruminant production (sheep and goats = 19; cattle = 6), while the remaining one-third (n = 11) dealt with cooperative capacity building. Hosts in the cooperative capacity building case study group were mostly women cooperatives and included farming communities that either raised small ruminants or processed dairy products. Approximately two-thirds of all case studies were conducted during the rainy season (June–September), while the remaining third were completed between October and May (dry season).

The EOA reports yielded 254 expert volunteer recommendations, which were assumed to be sensible indicators of current needs of smallholder livestock farming communities. To reduce redundancy and facilitate analyses, recommendations were streamlined into narrower sets of 21, 14 or 11 categories for case studies dealing with small ruminants, cattle or cooperative capacity building respectively. The number of recommendations in each category

Table 1. Summary of case studies by type of livestock, geographical location, season and approximate number of farmers involved.

	Region	**Case studies (n)**			**Number of farmers involved (approx)**
		Rainy season	*Dry season*	*Total*	
Small ruminants (sheep and goats)	Ségou	1	1	2	28
	Kayes		1	1	22
	Koulikoro	4	1	5	99
	Sikasso	10	1	11	440
Cattle (beef and dairy)	Koulikoro		1	1	22
	Sikasso	3	2	5	228
Cooperative capacity building (small ruminants and dairy)	Kayes	2		2	29
	Koulikoro	6	3	9	240

was expressed as a frequency. Assumed needs were then regrouped into broader topical areas and also expressed as frequencies. For case studies involving small ruminants or cattle, broader topical areas included animal feed and forage, animal health, animal reproduction, herd management, business administration and other (including community action and education and training). Broader categories for case studies involving cooperative capacity building included organization, business and finance, production, marketing and education and training. Frequency of needs in these broader categories were subjected to chi^2 goodness of fit to determine whether frequency distributions departed detectably ($p < 0.05$) from a uniform distribution (a situation in which all needs are similar) using SAS (v 9.3).

Given the variation associated with geographical region, season of assessment, main activity of cooperatives (small ruminants or dairy) and the diversity of expert volunteer backgrounds, we cross-tabulated our data with each of these potential sources of bias. We conducted chi^2 contingency tests to determine whether frequency of the most important smallholder need assessments was associated with any of these four factors. Separate analyses were conducted for each of the three case study types (small ruminants, cattle and cooperative capacity building), and within each of these subsets, category-by-category analyses were conducted, building frequencies for each broad need category versus frequency of all other assessed needs within each of the four sources of bias considered. Qualitative descriptions contained in SOW, EOA and IA reports were extracted and used to provide depth and context to the interpretation of smallholder livestock producer needs. These helped provide valuable insights into the relative constraints placed by cultural, organizational and biophysical factors on the ability of local farming communities to overcome livestock production challenges.

Results

Small ruminants

Most of these case studies were conducted in Koulikoro and Sikasso during the rainy season (Table 1). Frequency

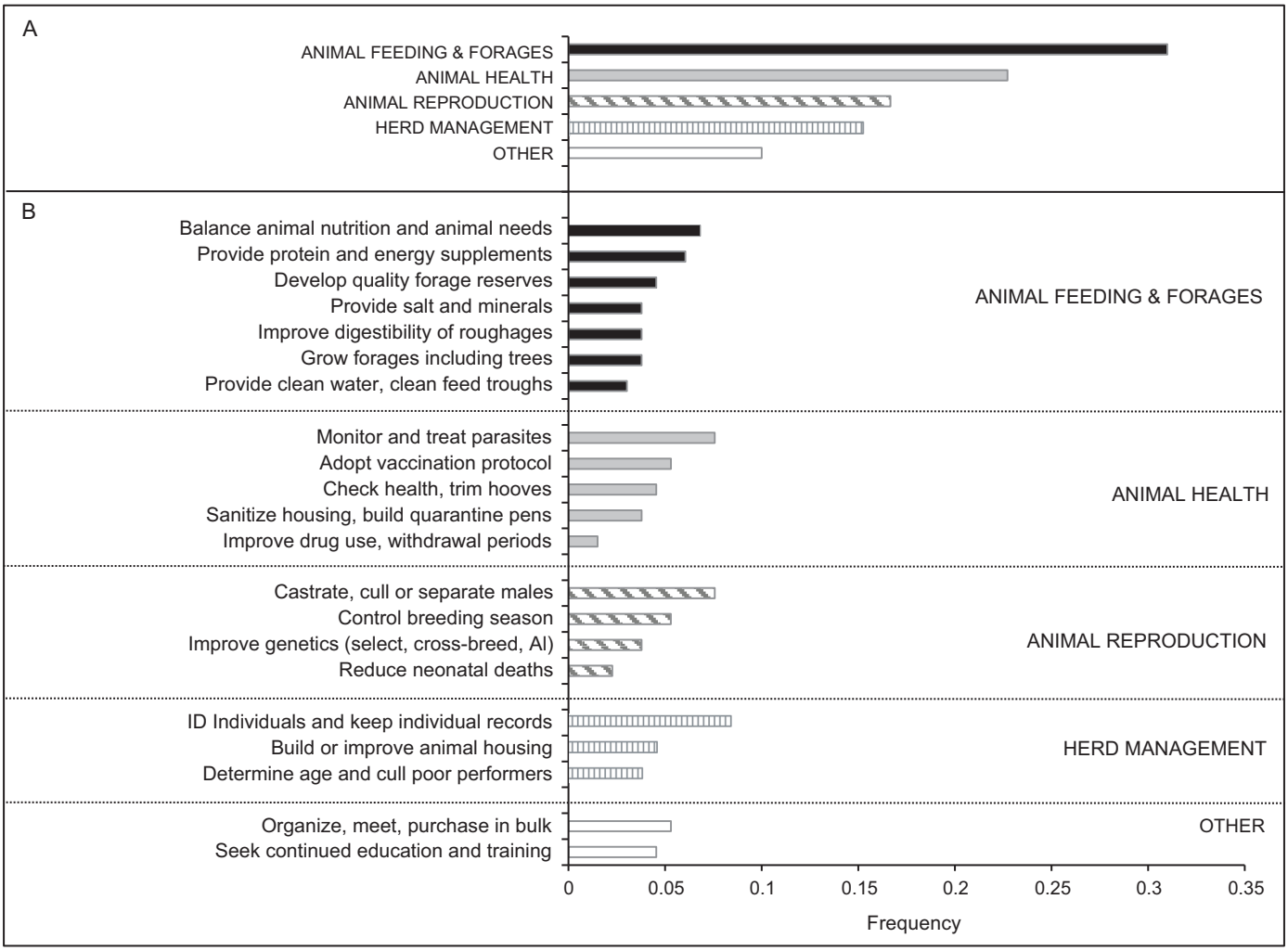

Figure 2. Frequency of Malian smallholder sheep and goat operations' needs based on assignments involving approximately 589 farmers from Ségou, Kayes, Koulikoro and Sikasso.
Note: Needs are grouped into broad categories (panel A) and specific needs in each broad category (panel B).

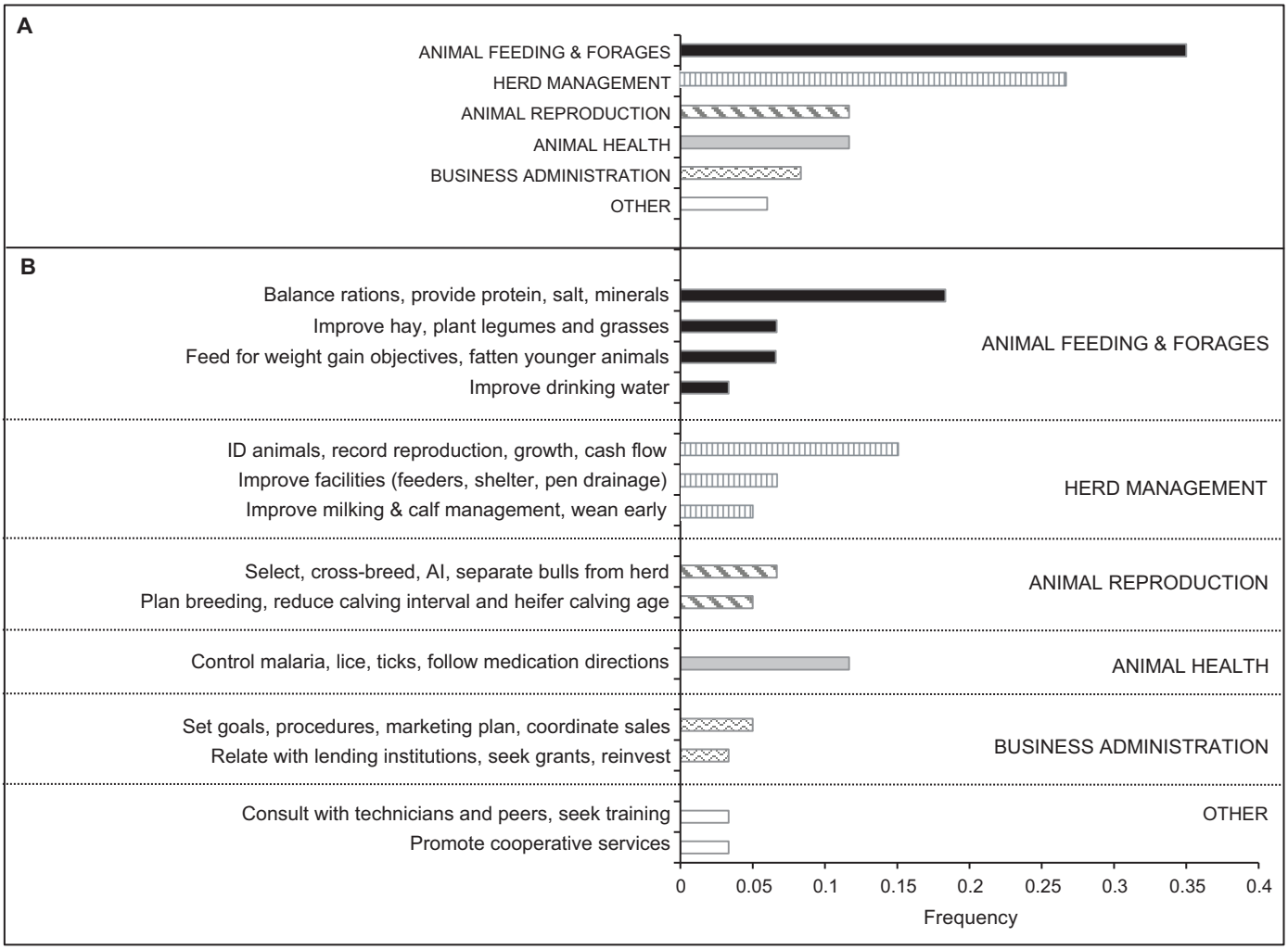

Figure 3. Frequency of Malian smallholder cattle operations' needs based on assignments involving approximately 250 farmers from Koulikoro and Sikasso.
Note: Needs are grouped into broad categories (panel A) and specific needs in each broad category (panel B).

distribution of smallholder sheep and goat producer needs grouped into broad categories departed significantly from a uniform distribution ($chi^2 = 17.3$; $p < 0.01$). Needs associated with animal feeding and forage were the most frequently assessed, followed in order of decreasing frequency by needs in the areas of animal health, animal reproduction, herd management, and other needs associated with community action and education and training (Figure 2). Within the category of animal feeding and forage, adjusting nutrition to animal physiological (reproductive or growth) stage was the most frequent need assessed (Figure 2). Use of protein and/or energy supplements and development and storage of forage resources for the dry season were the second and third most frequent recommendations. Provision of salt, minerals, clean water or the need to grow forage crops and improve the digestibility of roughages (particularly low-quality hay and straw fed during the dry season) were also repeatedly mentioned (Figure 2).

Animal health-related challenges were the second broad category of needs most frequently assessed (Figure 2). In this category, parasite treatment and monitoring was the most frequently cited need, followed by recommendations to adopt vaccination protocols as well as other preventive health management procedures. Improvement of animal housing sanitation conditions and appropriate use of drugs were the needs mentioned least frequently. The third most frequently assessed need involved reproductive management challenges, the most important of which was castration and handling of males. The need to achieve a greater degree of control over the breeding season was second in importance, followed by genetic improvement and reduction in neonatal deaths, which were the least frequently cited needs.

Although herd management-related needs were ranked fourth in importance, the need to identify animals (for example, by ear tags) and to keep individual records was the single most frequent suggestion in volunteer reports. Improvement of animal housing facilities and culling of older or unproductive animals were infrequent management recommendations. Community action or training and education ('other needs') were the least frequently assessed needs. The chi^2 tests suggested that the frequency of needs of smallholder sheep and goat producers was consistent across geographic regions, seasons and not affected by the background of volunteers involved in the

Table 2. Cross-tabulation of geographical location (region or biome), season, volunteer background and frequency of needs of Malian smallholder sheep and goat operations classified into four broad categories.

	Number of volunteer recommendations	Animal feed & forage	Animal health	Animal reproduction	Herd management
Region			*Frequency*		
Ségou	13	0.39	0.23	0.08	0.15
Kayes	4	0.50	0.00	0.25	0.00
Koulikoro	31	0.23	0.42	0.19	0.16
Sikasso	79	0.33	0.18	0.20	0.17
Chi^2		2.14	8.53	1.26	0.78
P		*0.54*	*0.04*	*0.74*	*0.85*
Assessment season			*Frequency*		
Rainy season	112	0.33	0.23	0.20	0.16
Dry season	15	0.20	0.27	0.13	0.13
Chi^2		1.04	0.09	0.34	0.08
P		*0.31*	*0.77*	*0.56*	*0.79*
Volunteer affiliation			*Frequency*		
Higher education institution	78	0.35	0.22	0.21	0.19
Non-governmental organization	35	0.13	0.38	0.00	0.25
Government organization	8	0.26	0.26	0.23	0.09
Retiree	6	0.50	0.17	0.00	0.00
Chi^2		3.18	1.24	3.75	3.71
P		*0.36*	*0.74*	*0.29*	*0.29*

Note: Need assessments derived from 127 recommendations from 19 case study assignments. Association significant at $p \leq 0.05$.

Table 3. Cross-tabulation of assessment season, volunteer background and frequency of needs of Malian smallholder cattle operations classified into five broad categories.

	Number of volunteer recommendations	Animal feed & forage	Herd management	Animal health	Animal reproduction	Business administration
Assessment season				*Frequency*		
Rainy season	33	0.37	0.26	0.19	0.07	0.07
Dry season	27	0.33	0.27	0.06	0.15	0.09
Chi^2		0.09	0.01	2.24	0.86	0.06
P		*0.75*	*0.91*	*0.14*	*0.35*	*0.81*
Volunteer affiliation				*Frequency*		
Higher education institution	14	0.57	0.29	0.00	0.14	0.00
Individual farmers – private owners	16	0.31	0.19	0.13	0.00	0.31
Non-profit – public interest NGO	22	0.27	0.32	0.09	0.23	0.00
Retiree	8	0.25	0.25	0.38	0.00	0.00
Chi^2		4.05	0.85	7.18	5.88	15.00
P		*0.26*	*0.84*	*0.07*	*0.12*	*<0.01*

Note: Needs assessment derived from 60 recommendations from six case studies. Association significant at $p \leq 0.05$.

assessment. A single instance of a statistically detectable ($p = 0.04$) association between animal health needs and geographic region was identified in case studies conducted in Koulikoro.

Cattle

Case studies involving cattle were conducted in Koulikoro and Sikasso during both the rainy and dry seasons (Table 1). Frequency distribution of smallholder cattle producer needs grouped into broad categories departed significantly from a uniform distribution ($chi^2 = 17.2$; $p < 0.01$). Needs associated with animal feeding and forages were the most frequently assessed (as with small ruminants), followed in order of decreasing frequency by needs in the areas of herd management, animal reproduction, animal health, business administration and other needs associated with education and training, and community action (Figure 3). Feeding balanced rations with adequate levels of protein, salt and minerals was not only the most frequently assessed need within the broad category of feeding and forages, but also the single most frequent volunteer recommendation to smallholder cattle producers (Figure 3). Growing forage crops (legumes and grasses) and feeding younger rather than older animals according to programmed weight gains were the next most frequently cited needs. Improvement of drinking water availability and quality was a need less frequently mentioned in volunteer reports.

Herd management challenges were the second broad category of needs most frequently assessed. In this category, the need to identify animals (using ear tags) and to keep records of individual animal production and operation finances was most frequently cited. This challenge was also the second overall most frequently assessed

specific need of cattle producers. Improvement of housing and handling facilities and management of cows (including milking in dairy animals) and calves (including early weaning) were the next most frequently cited challenges. Animal reproduction and animal health needs were the third most frequently assessed challenges in volunteer reports. Planned breeding and improvement in reproductive efficiency of cows were the specific reproduction-related needs assessed. Control of common illnesses and ectoparasites, closely following medication instructions, were the specific animal health challenges cited in volunteer reports.

Business administration challenges were ranked fourth and included the need to improve business planning and organization, as well as the development of a rapport with lending institutions so as to improve the availability of capital investment. As with sheep and goat smallholders, education and training and collective action recommendations were, overall, the least frequently cited. Due to the small number of case studies focusing on cattle production, cross-tabulation analyses evaluated possible biases associated with only two factors: assessment season and volunteer affiliation (Tables 2 and 3). We found a single case of statistically detectable ($p < 0.01$) association between the assessment of business administration needs and volunteer affiliation. This association was apparently driven by a higher frequency of business-related recommendations made by volunteers who were either farmers or private company owners from the USA.

Cooperative capacity building

All case studies focusing on cooperative capacity building were conducted in Kayes and Koulikoro, mostly during the rainy season (Table 1). Cooperatives were almost evenly split between small ruminant raising and dairy processing and were almost entirely women's cooperatives (Table 4). Frequency distribution of assessed needs grouped into broad categories once again departed significantly from a uniform distribution ($chi^2 = 15.2$; $p < 0.01$). Organizational needs were the most frequently assessed, followed in order of decreasing frequency by needs in the areas of business and finance, production (both meat and dairy), marketing and education and training (Figure 4).

Basic cooperative organizational needs such as developing a constitution and by-laws, holding elections for officer positions, defining roles of officers and collecting dues from members were the most frequently cited specific needs within the broad category of organizational challenges (Figure 4). The need to hold meetings regularly, to produce an agenda for each meeting and to develop consensus-building skills to run cooperative meetings successfully was ranked second (Figure 4). The need to keep records (meeting minutes, income and expenses), followed by the needs to ensure greater participation of women in positions of leadership and to share experiences with peer cooperatives were also cited, albeit less frequently.

Cooperative business and finance issues were the second most frequently cited. Volunteer assessments within this category dealt mostly with the need to develop business goals and plans, including strategies to grow the business by reinvesting cooperative profits. Finance needs such as the development of micro-credit lines for cooperative members or improvement of the cooperative's business rapport to access credit and

Table 4. Cross-tabulation of geographical location (region), sector, assessment season, volunteer background and frequency of needs of Malian smallholder cooperatives classified into five broad categories.

	Number of volunteer recommendations	Organization	Business & finance	Production	Marketing	Education & training
Region				*Frequency*		
Kayes	16	0.50	0.25	0.06	0.19	0.00
Koulikoro	51	0.35	0.22	0.18	0.12	0.14
Chi^2		1.09	0.08	1.25	0.51	2.45
P		*0.29*	*0.77*	*0.26*	*0.48*	*0.12*
Sector				*Frequency*		
Dairy	21	0.14	0.10	0.38	0.24	0.14
Small ruminants	46	0.50	0.28	0.04	0.09	0.09
Chi^2		7.74	2.13	12.93	2.83	0.48
P		*0.01*	*0.09*	*<0.01*	*0.09*	*0.49*
Assessment season				*Frequency*		
Rainy season	48	0.31	0.21	0.05	0.05	0.11
Dry season	19	0.58	0.23	0.19	0.17	0.10
Chi^2		4.07	0.03	1.95	1.52	0.01
P		*0.04*	*0.87*	*0.16*	*0.22*	*0.99*
Volunteer affiliation				*Frequency*		
Higher education institution	17	0.23	0.18	0.35	0.12	0.12
Individual farmers – private owners	3	0.67	0.00	0.33	0.00	0.00
Non-profit – public interest NGO	9	0.56	0.33	0.00	0.00	0.11
Other private enterprises	38	0.57	0.24	0.08	0.19	0.11
Chi^2		3.72	1.74	9.41	2.72	0.39
P		*0.29*	*0.62*	*0.02*	*0.44*	*0.94*

Note: Needs assessments derived from 67 recommendations.

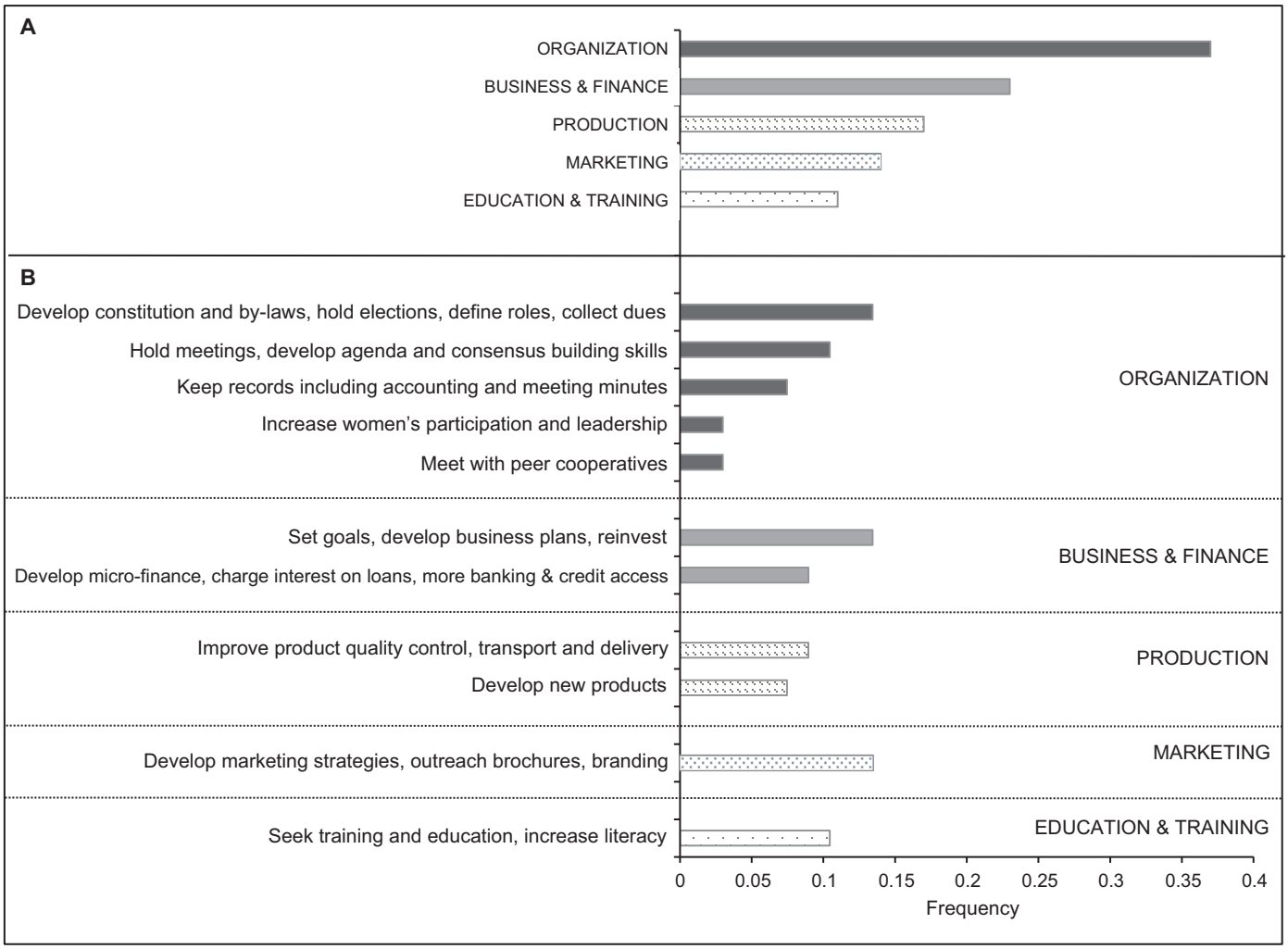

Figure 4. Frequency of Malian smallholder cooperatives' needs based on assignments involving approximately 269 farmers from Kayes and Koulikoro.
Note: Needs are grouped into broad categories (panel A) and specific needs in each broad category (panel B).

loans from banks were the next most frequently cited challenge.

Almost all needs assessed within the production category were associated with cooperatives that processed and marketed dairy products. Among these, improvement of quality control protocols, as well as transport and delivery efficiency, were the most frequently cited issues. Marketing and education needs were the least frequently mentioned, and involved aspects of branding and advertising strategies (mostly associated with dairy processing) or the need to seek additional training and increase levels of literacy among cooperative members.

Cross-tabulation chi^2 tests suggested that the frequency of assessed needs of smallholder cooperatives was consistent across geographical regions, and these were mostly unaffected by season or volunteer background, but, as expected, were strongly dependent on the type of production (Table 4). A single instance of a statistically detectable ($p = 0.04$) association between organizational needs and season was apparently driven by a higher frequency of this kind of need diagnosed in case studies conducted during the dry season (Table 4). We also found only one instance of statistically detectable ($p = 0.02$) association between production needs and volunteer affiliation; volunteers affiliated with higher education institutions or farmers in the USA were apparently more likely to identify production-related needs. Production-related needs were more frequently assessed in dairy cooperatives ($p < 0.01$), whereas the opposite was true of needs associated with cooperative organization ($p = 0.01$). Business and finance needs tended to be assessed more frequently in small ruminant cooperatives ($p = 0.09$), while marketing recommendations were more frequent in the dairy cooperative case studies ($p = 0.09$).

Discussion

Almost three decades after the ILCA project, productivity of smallholder livestock herds continues to be limited mainly by animal feeding challenges. Regardless of region, season or volunteer affiliation, the most frequently assessed needs of small ruminant and cattle smallholders were associated with animal feeding and forage supply. Providing balanced rations and adjusting nutrition to

animal reproductive or growth stage, growing forage crops, and improving the quality of drinking water, were the specific needs most frequently identified. In agreement with the recent literature (Turner and Hiernaux, 2002; Hamer *et al*, 2007; Turner and Hiernaux, 2008; Brottem *et al*, 2014), expert volunteers pointed to farmers' limited knowledge of animal husbandry, difficulty in bridging the dry season forage gap and restrictions in animal mobility caused by land use conflicts during the rainy season (crops versus grazing animals) as the most probable causes underlying the livestock feeding challenges.

Despite the apparent lack of progress in animal feeding practices and the broader challenges identified in our case studies, impact assessment reports showed several instances in which relatively modest efforts to overcome constraints resulted in tangible productivity improvements. In at least two case studies, farmers reported that hiring a Fulani herder, broadly recognized in West Africa as being the most knowledgeable in livestock husbandry (Turner, 1999a), to overcome expertise limitations, resulted in increased production and lowered neonatal mortality in dairy cattle and small ruminants. In another case, farmers reported reductions in neonatal mortality rates of goats and sheep by improving the dry season nutritional management of gestating does and ewes. In a fourth case study, women in a village in central Mali who had attended training on the forage attributes of cassava (*Manihot esculenta*) reported that supplementing goat diets with dry foliage of this species increased milk production noticeably. Cassava is grown primarily in Ségou and Sikasso and is the only crop that maintains green leaves during the dry season (Levasseur *et al*, 2004). When fed as a supplement in the form of silage or hay, its foliage has been shown to increase weight gains and milk production (Hue *et al*, 2010; Oni *et al*, 2010; Thang *et al*, 2010). In both the gestation feeding and cassava supplementation cases, farmers found ways to overcome the severe constraints imposed by the dry season forage gap. Collectively, these anecdotal accounts suggest that opportunities for modest improvement in livestock productivity appear to be well within reach of village communities, particularly if effective local extension programmes are made available to smallholders.

The established practice of fattening sheep and goats for *Tabaski* (Moslem Feast of the Sacrifice) suggests that the value of improved animal feeding practices is well understood among rural households in Mali. During the weeks leading up to this feast, rams fed in confinement achieve up to double the average daily weight gains of their extensively raised counterparts (Kolff and Wilson, 1985). Dalton and Masters (1998) argued that intensification of livestock feeding in agro-pastoral communities of southern Mali could be induced by taxing the use of communal grazing lands. They reasoned that 'grazing on the commons remains more attractive to the representative household than adopting more labour-intensive and capital-intensive confinement systems' (p 27). However, fee-based use of grazing lands in other regions of Mali has apparently not induced the adoption of intensive confinement feeding systems; nor has it fostered the use of intensively planned grazing schemes on pastoral lands (Badini *et al*, 2007; Roncoli *et al*, 2007). Thus, intensification of livestock feeding practices is probably unlikely to occur due to the fact that animal mobility remains a critical element of smallholders' strategies to adapt to climate variability (Brottem *et al*, 2014; Turner *et al*, 2014). Turner *et al* (2014) found that in northern Mali about 70% of livestock (mostly cattle) move out of the village territory during the rainy season and 51% move into the village during the dry season. The high value placed on animal mobility is also thought to explain partially the low level of adoption of woody legume forage banks, a technology long championed by research and development agencies (Thomas and Sumberg, 1995; Hamer *et al*, 2007). Livestock smallholders in Mali and most of Sub-Saharan Africa are apparently disinclined to invest money and effort developing a static fodder source (a need frequently assessed by expert volunteers in this study) at the expense of reduced animal mobility (Thomas and Sumberg, 1995).

During the early 1980s, Wilson (1987) noted a decline in weights and body size of cattle in the area of Niono, which he partly attributed to diminished feed resources on pastoral lands. Although the case studies analysed in this paper did not involve addressing pastoral land use issues, overcoming the feeding challenges of agro-pastoral livestock smallholders will require addressing not only basic ruminant nutrition concerns, but also broader challenges associated with communal grazing areas. Emerging trends in common land use and property rights (Roncoli *et al*, 2007; Brottem *et al*, 2014) and emigration of pastoral community members to urban areas (Turner, 1999a, 2009) suggest that overcoming animal mobility and livestock husbandry-related constraints may become increasingly challenging in the future.

The relative frequency with which animal health, reproduction and herd management needs were assessed varied, depending on whether smallholders raised small ruminants or cattle. In both cases, however, endo- and ectoparasite control, breeding season control and individual animal record keeping were the specific needs most often assessed. All these specific needs (except for health-related issues) were consistent across regions, season and volunteer affiliation. Animal health-related needs of sheep and goat smallholders were more often cited in case studies conducted in the region of Koulikoro.

Earlier studies on the incidence of livestock diseases in central Mali attributed most morbidity and mortality losses to malnutrition (Traore and Wilson, 1988). Case studies analysed in this paper were unable to assess the proximal causes of reported mortality problems. However, expert volunteers observed that farmers were usually highly concerned about their animals' welfare and health. Impact assessment reports found that once training was provided, farmers rapidly learned to follow vaccination protocols and to use behaviour observation as a diagnostic tool for early disease detection. Our results agree with previous research showing that training can significantly improve farmers' ability to recognize and treat livestock diseases such as African animal trypanosomosis (Liebenehm *et al*, 2011), and suggest that significant improvement in this area could be achieved with effective extension outreach programmes.

As with animal feeding challenges, livestock reproductive management needs identified in the case studies were

similar to those described by the 1980s ILCA project. Wilson and Durkin (1988) reported that lack of control of the breeding season and year-round births were common in central Mali. Our results suggest that this is still a prevailing practice. The Mali ILCA study found that season of birth was highly correlated with small ruminant litter sizes (Wilson and Sayers, 1987), cattle survival rates (Traore and Wilson, 1988) and lifelong patterns of weight gain and fertility of both small ruminants and cattle (Wilson, 1987). These results underscore the critical importance of reproductive management as a means of improving herd productivity indicators. However, according to IA reports, castration of males and separation of reproductively mature males and females were the management practices that met the largest resistance among smallholders involved in our case studies. Consumers apparently show lower preference for adult castrated males, which fetch lower market prices. Additionally, the deep-rooted notion that raising males and females together increases opportunities for conception (and thus maximizes reproductive output) further hinders the possibility of addressing reproductive management challenges.

The lack of a system to identify individual animals and the consequent absence of individual production records were identified as serious constraints hindering smallholders' ability to track their flocks/herds and cull poorly performing animals. Amanor (1995) suggested that the structure of West African cattle herds (for instance, males versus females, or young versus old) closely reflected a herder's strategies to cope with changing demand in regional livestock markets. It is possible that local markets in the villages we studied favoured the sale or trade of adult animals, and that smallholders were therefore not focused on establishing a stable core of high-quality reproductive females, as occurs in Western livestock-raising enterprises. In this context, and despite multiple instances of ear-tag equipment donations from volunteers, farmers may have been reluctant to invest time and effort in identifying and selecting the best dams in their herds. Alternatively, literacy constraints may have hindered the adoption of animal ID and production record keeping. Amadou *et al* (2012) studied peri-urban smallholder livestock raising in Sikasso and found no relationship between illiteracy levels and willingness to adopt improved management practices. Nonetheless, record keeping and animal ID were not addressed in that study. Further research into the factors determining smallholders' marketing strategies could provide opportunities to develop place-adapted guidelines for improved reproductive management and animal selection.

Malian government decentralization policies of the 1990s fostered the creation of a large number of grass-roots organizations such as farmer cooperatives, and provided strong incentives to organize by channelling much of the technical and financial support to farmers through these organizations (Coulibaly *et al*, 2010). Cooperative capacity building was therefore the focus of approximately a third of our case studies. Many of the cooperatives were formed by women who sought to boost household incomes by cooperating on small ruminant-raising or dairy-processing enterprises. Bambara names given by women to their cooperatives such as *Dièma* (Closely knit), *Faso Yiri Wa Ton* (Home welfare), *Sigi Tè Mogo Son* (Stand up and act) or *Benkady* (Together we are strong) provide a sense of their vision and the essence of these organizations. Despite the clear spirit of collective action and governmental incentives, serious deficiencies were found in the day-to-day functioning of most cooperatives in our case studies. In most cases, by-laws had not been developed, meetings were not held regularly, officers had not been elected and cooperative finances were in disarray. Not surprisingly, organization needs were the most frequently assessed by expert volunteers. High levels of illiteracy as well as the accepted social role of women in rural communities were identified as the most significant factors constraining women's ability to run their organizations effectively and benefit from cooperation efforts. Interestingly, women's cooperatives showed the highest levels of entrepreneurial motivation and were the most likely to test new ideas suggested by expert volunteers. Impact assessments showed consistent positive change in almost all participating women's organizations, ranging from the launching of a new cooperative enterprise (such as shared sheep fattening for sale during *Tabaski*) to testing the development of new dairy products for sale in their communities. Based on these observations, we believe that women's smallholder organizations in agro-pastoral communities of Mali will be the most likely to adopt improved management practices and seize opportunities for change. Interventions aimed at increasing levels of adult literacy could have an extraordinary impact on improving the efficacy of grass-roots organizations.

Conclusions

Assessment of smallholder needs suggests that progress in livestock production in Mali since the 1980s has been extremely slow. Most of the challenges identified are similar to those reported by the ILCA project almost three decades ago. Addressing the most basic livestock feeding challenges will require an integral approach encompassing pastoral land grazing and strategic use of crop residue resources. Although our analysis classified smallholder needs into discrete categories, we realize that animal feeding, health and reproduction, as well as herd management and farmer organization needs are interconnected. Meeting the feeding and forage needs of small ruminants and cattle will be difficult to achieve without concurrent control of the breeding season and common diseases, as well as the implementation of place-appropriate methods to track and cull unproductive animals. Empowerment of grass-roots organizations, particularly women's cooperatives, through literacy programmes and effective extension outreach, could have significant impacts on the improvement of smallholder livestock enterprises.

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