Participation and its determinants in East Cost Fever immunization by small-scale cattle keepers in Mazabuka district of Zambia

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SUMMARY

Currently 1.4 million cattle are at risk of East Coast Fever out of approximately 3 million in Zambia. A cross sectional study was carried out in Mazabuka district of Zambia from July to September 2015, to assess participation and factors affecting cattle farmers participation in ECF immunisation by the infection and treatment method. The study involved 224 randomly selected small scale cattle farmers from three veterinary camps in Mazabuka who participated in the second round of 2015 immunisation campaign. Semi-structured questionnaire was administered to consented farmers to seek information about demographic and socio-economic characteristics, knowledge and experience in cattle rearing, herd characteristics, management and perceived benefits, costs and challenges of ECF immunisation. Data on immunisation statistics, schedules, coverage, adequacy, vaccine delivery, successes and challenges were collected from the district veterinary office and the Central Veterinary Research Institute covering the period between the years 2008 to 2014. Descriptive statistics such as frequencies and proportions were computed to establish immunization coverage, participation trend and socio-demographic parameters of cattle farmers. Fischer exact test was used to assess associations between variables at 5% significance level. Logistic regression was run using R software to assess influence of different factors on willingness of farmers to participate in immunization campaign. Majority of participants were males (94%), had secondary education (49.1%), more than five year experience of keeping cattle (89.3%) and depended on sources other than cattle for their livelihood (47.3%). From 2008 to 2014 vaccination coverage was on average 65% of the target per annum and 97% of the participants appreciated reduction in cattle mortality post immunisation. Willingness to participate in immunisation campaign was influenced by education level (secondary education: OR=27, 95% CI: 2.29-352.71), satisfaction with immunisation service (OR=5.14, 95% CI: 1.04-24.64) and experience of post-immunisation mortality reduction (OR=7.33, 95% CI: 1.26-44.00). Improvement in service delivery quality and monitoring of post immunisation outcome can lead to increased participation of farmers in immunisation campaigns.

Key words: East Coast Fever, immunisation, Infection and Treatment Method, Theileriosis, Tick Borne Diseases, Mazabuka

INTRODUCTION

East Coast Fever (ECF), a form of theileriosis, is a protozoan tick borne disease affecting cattle. The causative protozoa, *Theileria parva*, are transmitted by ixodid tick, *Rhipicephalus appediculatus* ("brown ear tick"). It is a fatal disease with mortality ranging from 80% to 100% in endemically unstable conditions. It causes about 1.1 million deaths annually and 28 million cattle are at risk in the Eastern, Central and

Southern Africa. Total annual monetary losses in these countries were estimated at US$ 168 million (Mukhebi*et al.*, 1988). This may be an understatement as ILRI (2014) contends that 60% of the 75 million cattle in the sub-region are at risk of ECF.

In Zambia, the first case of ECF was recorded in 1922 in Nakonde in northern Zambia. Since 1947, ECF has spread within the Northern and Eastern Provinces where the disease is endemic. The disease has also established itself endemically in Southern Province since the malignant form of theileriosis was recorded there in 1977 (Nambota *et al.*, 1994)**.**

ECF has traditionally been controlled by vector control, mainly by use of expensive acaricides and chemotherapy using effective derivatives of naphthoquinone compounds (parvaquone and buparvaquone). The other practical methods include control of cattle movements and immunisation by Infection and Treatment Method (ITM) (Muleya *et al*., 2012).

Immunisation against ECF by ITM dates as far back as 1967-76 when a Food and Agriculture Organisation (FAO) Tick-borne Project at Muguga, Kenya, established stabilates of cryopreserved ECF sporozoites for immunisation trials (Brown,1985). ECF immunisation concept arose from observations of naturally acquired immunity and involves an elaborate infection-and-treatment strategy.

In Zambia, immunisation by ITM has been carried out in Southern and Eastern Provinces using the Chitongo and Katete stocks of *T. parva* respectively, since late 1980s (Morzaria *et al.*,1999). Immunisation can impart lifelong immunity if infected ticks continue to challenge the immunised animals regularly (Gachohi *et al*.,2012). Zambia currently imports the vaccine from the Centre for Ticks and Tick Borne Diseases (CTTBD) in Malawi.

Although the delivery of the vaccine is expensive(Mukhebi and Perry, 1992), immunisation is a preferred long term measure of ECF in enzootic areas even if some strategic tick control is still required. Long term costs incurred in case of immunisation are considerably lower than in case of life-long acaricide control (Mukhebi *et al.,* 1988). The ultimate aim of ECF immunisation is to attain endemic stability which Billiouw *et al.*(1999) defines as a state where all calves less than 6 months old, have been in contact with *T. parva* while clinical disease is rare. Calculations based on data from Southern Province, Zambia, show that large-scale ECF immunisation reduces the total economic cost (TEC) by 90% compared to no intervention. TEC refers to the sum of output losses from tick damage, theileriosis mortality and morbidity, and expenditures for treatment or prevention of the disease (D'Haese*et al.*, 1999).

Whilst the delivery process in Zambia is solely undertaken by the Government, the perception and behavior of farmers in connection with ECF immunisation, and the identification of determinants of immunisation, are the missing critical information if more farmers have to be mobilised to immunise their cattle. This study, therefore aimed at assessing the ECF immunisation exercise so as to suggest improvement strategies. In particular, the study wanted to establish the perception and proportion of small-scale cattle farmers participating in ECF immunisation and identify the determinants of farmers' participation in ECF immunisation.

MATERIAL AND METHODS

Study design and selection participants

This cross-sectional study involving small-holder cattle farmers was conducted in Mazabuka district from July to September 2015. Mazabuka district is located on the plateau of the Southern Province of Zambia. It lies at latitude 16°S and longitude 28°E at an average elevation of 1102 metres above the sea. It has a unimodal rainfall pattern, receiving above 815 mm of rainfall per annum. The temperatures are moderate to high, ranging between 12°C and 33°C. The seasons may be divided into hot wet, cool dry and hot dry seasons.

A three stage – sampling design was used i.e. from the district; three veterinary camps with highest number of the households namely Ngwezi, Kalambabakali and Hanjalika were purposively selected. In Zambia, a veterinary district is administratively subdivided into areas called veterinary camps which are manned by Veterinary Assistants (VA's).

The sample size of respondentswas determined by using Yamane formula $n = N/[1+N(e)^2]$ (Israel, 2013), where n is required sample size, N population size and e is the level of precision. At 95% confidence level, precision of 5% and proportion of households participating in immunization P was set at 50%, the sample size was calculated based on a finite population of 504 households who participated in the 2014 campaign.This translated into 224 households to participate in this study.A total of 27 villages were randomly picked with 19 comprising eight households each and eightcomprising nine households each translating into a sample size (n) = 224.

Data Collection

Primary data were collected by means of apre-tested semi-structured questionnaire which was administered to the respondentsby three trained Veterinary Assistants. The questionnaire sought information on demographic, socio-economic characteristics of participants, their knowledge, practice and experience in cattle rearing and data on herd characteristics were gathered. To assess the perception of the small scale cattle farmer on immunisation data were collected on perceived benefits, costs and challenges of ECF immunisation. The questionnaire also captured data on immunisation schedule, satisfaction andwillingness of farmers to participate in the immunization campaigns.

Secondary data on schedules, coverage, adequacy, vaccine delivery, successes and challenges were collected from the district veterinary reports (2008 to 2014) and the Central Veterinary Research Institute (CVRI). Moreover, in-depth interviews with veterinary service authorities and personal communication were used as complementary methods to gather information of ECF immunisation campaign in Mazabuka.

Data analysis

Descriptive statistics such as frequencies and proportionswere used to get information on demographic data (age, marital status, gender, household size, education level, and experience in cattle rearing) and economic status data (sources of income, labour, size of herd, livelihood from cattle).This approach was also used to assess the perception and participation of small scale cattle farmers in ECF immunization campaign. Participation was calculated as the proportion of respondents who participated in the last 2015 vaccination exercise. Coverage was

determined by the percentages of targeted number of animals immunised since 2008. Adequacy was determined by the doses of vaccine the district received compared to the target cattle population to be immunised

Fishers' exact test was used to test for associations between various categorical variables at 5% significance level.

Factors affecting willingness of farmers to participate in immunization were quantified by stepwise logistic regression using Generalized Linear Model function in R software. Willingness to participate in the next campaign (outcome variable) was fitted in a multivariable model including the following explanatory variable; education level, herd size, cattle breed, labour source, farming experience, latest immunisation participated, immunisation service satisfaction, affordability, immunisation subsidy awareness, willingness to pay for immunisation, post immunisation mortality, and schedule observance. Goodness of model fit was assessed by Likelihood Ratio Test using *lmtest* package.

RESULTS

Socio-economic status of participants

A total of 224 respondents were interviewed, of whom 94% were male. All the respondents were small scale cattle farmers with only 6% owning 100 or more heads of cattle. Many of them were subsistence farmers, with 47% of the respondents largely dependent on cropping as their major source of income. Of the other 47% who depended on more than one source of income, 75% depended on cropping and milk sales and a cumulative total of 90% respondents had a component of cropping as one of the major sources of income. Three percent of respondents kept cattle only and 97% kept cattle and other livestock which included sheep, goats, pigs and poultry. No respondent kept pure exotic breeds of cattle. About 39%, kept the indigenous Sanga breeds (Tonga Breed) and 26% kept crosses while 35% kept mixed breeds. Approximately 89% of the farmers had at least five years of cattle keeping experience. About 49% of respondents had attained at least junior secondary education while 2% did not have any formal education background (Tables 1).

Table 1: Socio-economic characteristics of small holder cattle keepers in Mazabuka district (n=224)

Factor	Category	Frequency (percentage)
Sex	Female	13 (5.8)
	Male	211 (94.2)
Age (years)	< 25	3 (1.3)
	25-60	161 (71.9)
	>60	60 (26.8)
Level of education	None	5 (2.2)
	Adult education	1 (0.5)
	Primary	90 (40.2)
	Secondary	110 (49.1)
	Post-secondary	18 (8)

Table 1. continue..

Experience in cattle rearing (years)	<5	24 (10.7)
	5 - 10	68 (30.4)
	11 - 20	82 (36.6)
	>20	50 (22.3)
Source of income	Cattle	6 (2.7)
	Cropping	106 (47.3)
	Formal employment	3 (1.3)
	Other businesses	3 (1.3)
	> one source	106 (47.3)
Cattle herd size	1-9	69 (30.8)
	10-49	124 (55.4)
	50-99	18 (8)
	≥100	13 (5.8)
Livelihood from cattle	Milk for sale	18 (8)
	Animal/beef for sale	3 (1.3)
	Animal draft power	72 (32.1)
	Manure	1 (0.5)
	Mixed roles	130 (58)

Coverage, adequacy and participation of small scale farmers inECF immunisation

From 2008 to 2014 the district targeted to immunise 48, 000 heads of cattle, out of which 31,093 were immunised. This constituted 65% coverage.

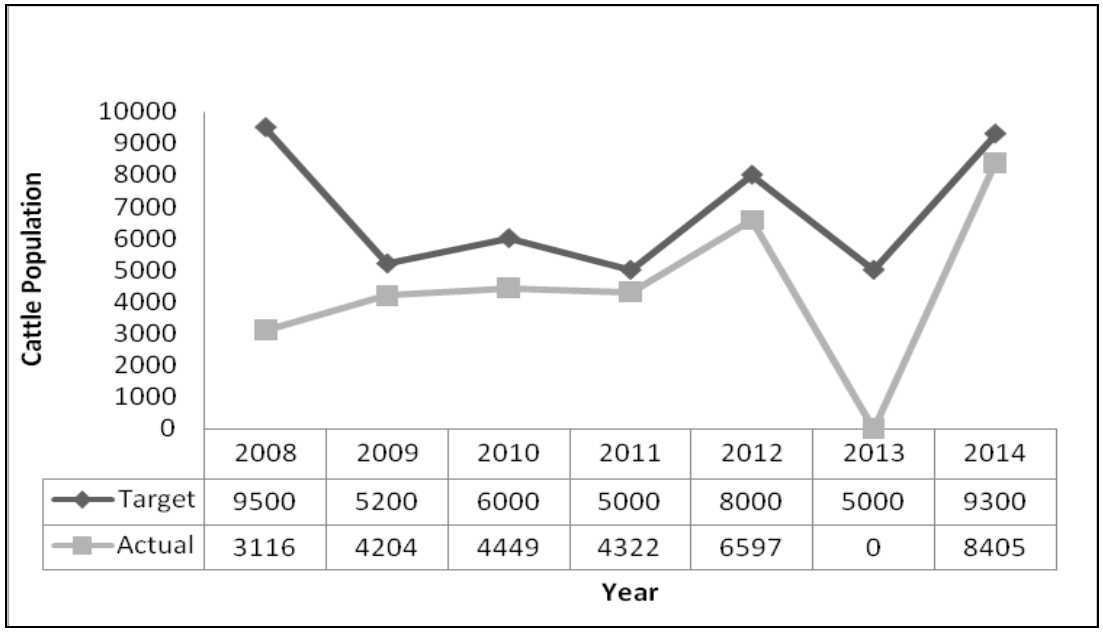

Figure 1: ECF immunisation trend from 2008 to 2014 (Mazabuka District Veterinary Office)

In 2008, the district could only manage 33% coverage. In 2012 the district ran out of the vaccine before completion of the campaign and in 2013 the district did not conduct any ECF immunisation because the Department of Veterinary Services (DVS) did not procure the stabilate from CTTBD.
In the first round of 2014 immunisation, the district overshot the target of 4300 and immunised 5835 animals. For the second round which targeted 5000 cattle, the district received 7000 doses of the vaccine. Of these, 220 doses were spoiled and 4210 doses were returned to CVRI. This showed inconsistencies in the immunisation coverage and schedules (Fig.1)

Seventy three percent of the respondents or 163 respondents were recorded as having participated in the second round of the 2015 immunisation campaign.

Ninety five percent of respondents agreed that the delivery of immunisation wascarried out according to the announced schedule and 84.3% were satisfied with the delivery.

Vaccine delivery, administration and post-immunisation monitoring

In Zambia, ECF vaccine delivery was entirely carried out by the DVS. From CTTBD, the ECF stabilates were delivered to CVRI for storage, and then taken to provincial stores where distribution was done to respective districts according to the demand. In the districts, the stabilates were carried to the field using vehicles or motorbikes. The district organised immunisation centres where farmers brought their animals for immunisation. Farmers paid a subsidised price for immunisation pegged at Zambian Kwacha, (ZMK) 15.00 (about US$ 1.50) per calf (CVRI, Personal communication, 2015).

Post-immunisation monitoring of ECF immunisation was done 2 to 4 weeks after theactual immunisation. The monitoring involved clinical examination of the immunised animals in addition to the obtaining of both blood and lymph samples. The planned monitoring involved random sampling of camps, households and immunised animals. Concerted efforts by the district office and the farmer(s) were made to follow up reactors when reported by the farmer(s). Only one reactor was officially reported in Ngwezi camp and followed up in 2014.

Farming and ECF control practices

The study assessed the attributes of herd characteristics and management practices so as to determine whether these attributes had an influence on control of ECF especially so when ITM was used as a means of control.

Tick borne diseases (TBD's) were found to be the most common diseases, with 57% of the farmers recognising ECF as the commonest disease.ECF and other TBD's, including anaplasmosis, babesiosis and heartwater caused 97% mortality of the major cattle diseases in Mazabuka. The majority of farmers (78%) had at one time or another experienced ECF in their herds. From the Mazabuka district veterinary office 2014 annual report, 56% of mortalities were caused by ECF among major cattle diseases.All the farmers used acaricides to control ticks, either by dipping (42%) or spraying, using a spray race or by hand spraying (58%) during both dry and rain season. Table 2 summarises the experience of farmers in cattle rearing and ECF control practices.

Table 2: Farming practices and ECF control strategies in Mazabuka district (n=224)

Variable	Category	Frequency (percentage)
Farmers' ECF experience	Experienced	175 (78.1)
	No Experience	49 (21.9)
Chemotherapy of ECF	Have used drugs	178 (79.5)
	Have not used drugs	46 (20.5)
Cost of drugs	Affordable	201 (89.7)
	Not affordable	23 (10.3)
Cattle breeds	Local	88 (39.3)
	Crosses	58 (25.9)
	Mixed breeds	78 (34.8)
Cattle diseases experienced	ECF	128 (57.1)
	Other TBD's	7 (3.1)
	Black quarter	57 (25.5)
	Other diseases	32 (14.3)
Tick control dry season*	Once per week	161 (71.9)
	Once per 2 weeks	56 (25.0)
	> 2 weeks	7 (3.1)
Tick control in rainy season*	Once per week	201 (89/7)
	Once per 2 weeks	22 (9.8)
	> 2 weeks	1 (0.5)

Perception and participation of farmers on ECF immunisation campaign

The study assessed the perception of farmers on ECF immunisation to establish the performance of ECF immunisation campaigns with 97% of respondents agreeing that the exercise had appreciable benefits especially increase in productivity of the cattle. The majority of farmers (73%) participated in the second round of the 2015 immunisation campaign. However, 212 farmers (94.6%) were not willing to pay full immunisation cost. The associations between farmers' participation in the second round of 2015 campaign and various variables, tested with Fisher's exact test are indicated in Table 3.

Table 3: Associations between farmers' participation in second round of 2015 immunisation and various factors tested with Fishers' exact test

Variable	Category	Participated	Not Participated	Total	% immunising	*p* value
Education	None	3	2	5	60	0.535
	Adult	1	0	1	100	
	Primary	64	26	90	71	
	Secondary	84	26	110	76	
	Post Sec.	11	7	18	61	
Age of household leader (years)	<25	3	0	3	100	0.612
	25 to 60	118	43	161	73	
	>60	42	18	60	70	
Cattle Population	1 to 9	44	25	69	64	0.013
	10 to 49	98	26	124	79	
	50 to 99	15	3	18	83	
	≥100	6	7	13	46	
Years of cattle rearing	<5	16	8	24	67	0.709
	5 to 10	49	19	68	72	
	11 to 20	63	19	82	77	
	>20	35	15	50	70	
subsidy awareness	Yes	68	21	89	76	0.321
	No	95	40	135	70	
Calf mortality reduction	Yes	161	54	215	75	0.000
	No	2	7	9	22	
Farmers' satisfaction	Yes	149	40	189	79	0.000
	No	14	21	35	40	
Farmers' ECF Experience	Yes	127	48	175	73	0.928
	No	36	13	49	73	

There was significant association between farmers' participation and the size of the herd of cattle (p<0.05).There was also asignificant association between farmers' satisfaction with ECF immunisation and their participation (Fishers' exact test, p<0.05).Further, a significant association between reduction in calf mortality and farmers' participation was recorded. Farmers expressed satisfaction with immunisation and cited reduction in calf mortality as one of the benefits of immunisation.

The level of farmer's education, their age, and their experience in cattle rearing had no significant influence on farmers' participation in immunisation. Farmers' experience with ECF, i.e. whether they had experienced ECF or not in their herds, in the past five years, was not a factor on farmers' participation, neither was it a factor on affordability of the subsidised vaccine.

Factors affecting willingness of farmers to participate in ECF immunisation campaign

The final multivariable logistic regression model had three variables namely; level of education, immunization service satisfaction and post immunization mortality reduction.

The odds of participation among those with secondary education was 27 times the odds of those with only informal education. However, the influence of other education categories, primary and post-secondary education, were not statistically significant(Table 4). On the other hand, participants who were satisfied with ECF immunisation services were five times more willing to participate in coming vaccinations than unsatisfied ones. Moreover, participants who appreciated reduction of mortalities after ECF immunisation had seven times odds of participating in future campaigns than those who did not experience reduction in mortality (Table 4). Goodness of model fit test gave a p-value of 0.487 (chi-square statistic of 5.45 at 6 df) which suggests a good fit.

Table 4: Distribution of farmers willing to immunize cattle and Odds Ratios for final model variables (n=224)

Variable	**Category**	**Observations** (n=224)	**% willing to immunise**(n =213)	**OR**	**95% CI**
Education level	Informal	6	1.9	1.00	
	Primary	90	39.9	8.72	0.88 – 73.13
	Secondary	110	50.7	27.00	2.29 – 352.71
	Post-secondary	18	7.5	7.27	0.52 – 118.48
Service satisfaction	No	35	13.6	1.00	
	Yes	189	86.4	5.14	1.04 – 24.64
Post immunisation mortality reduction	No	9	2.3	1.00	
	Yes	215	97.7	7.33	1.26 – 44.00

DISCUSSION

Tick Borne Diseases are one of the major limiting factors to cattle productivity in Eastern, Central and Southern African regions because of the associated high morbidity and mortality rates (Kiswaga *et al*. 2006). Infection and treatment method has gained popularity as cost effective ECF control option (Martins et al. 2010). Generally, majority of farmers in the present studyappreciated better productivity in immunised animals compared to non immunised animals. They cited increase in weight gain by calves, milk production and reduced mortality in immunised animals. However, lower participation in immunization was observed in Mazabuka compared to other areas such as Kenya and Tanzania. The reasons may include low economic returnsof small-scale system in whichlow productivity makes the vaccine unaffordable and/ or dependency from other livelihood sources. In Uganda the immunisation performed well with exotic breeds (Nsubuga-Mutaka et al. 2000) while in northern Tanzania pastoral communities are reported to be highly motivated to participate and had a larger proportion of their cattle immunised (Di Giulio *et al.* 2009).This findingsuggests that the degree of livelihood dependency on cattle can play an important role in ECF vaccine uptake by farmers regardless of immunisation cost. This was a case evidenced by Randolph *et al*. (2003) who reported that higher price of the vaccine did not discourage uptake by small scale dairy farmers with improved breeds cattle in Kenya because it is highly effective and needs only one time administration. Farmers in Mazabuka expressed unwillingness to pay full cost as it might not be profitable because they

kept local indigenous or cross bred cattle. Furthermore, livestock is not the primary source of livelihood for these farmers. Studies from northern Tanzania showed an overwhelming response to immunisation from pastoralists where calves were vaccinated at full cost of between US$ 6 – 7 per dose (Di Giulio *et al.* 2009). Pastoralists depended solely on livestock and livestock products for sustenance and income (Msuya, 2013). In Tanzania, pastoralism is practiced in 'traditional grazing areas' where climatic and soil conditions generally do not favour crop production (Lynen et al., 1999). Pastoralists drew their livelihood primarily from cattle and this may account for the overwhelming response, unlike in Mazabuka district, where farmers, largely depended on cropping for their livelihood.

ECF immunisation coverage in Mazabuka was in most cases below 100%. The government institutions being sole key player in practical acquisition, storage, delivery and administration of vaccine could be among the reasons for low coverage as acquisition, delivery and administration consistency depended on government resource allocation. The vaccine delivery chain could be improved by public-private sector partnership under commercial grounds (Toye and Ballantyne, 2015). This approach may answer the question of consistence and sustainability which are prone to common resource inadequacy in developing countries like Zambia.

Monitoring of vaccinated animals for 2-4 weeks post-immunization and treating reactors is essential to ensure desired outcome (Di Giulio *et al.* 2009). It should involve examination of animals for clinical signs and taking samples for laboratory assessment. This approach reduces post immunisation mortalities and may identify deaths due to causes other than ECF and preserve the trust and confidence of livestock owners. Reduction in mortalities is one of indicators of improved productivity as declared by respondents in the present study and it has been statistically quantified as an influential factor for immunisation participation willingness. Accounting for it during planning and implementation of immunisation campaign may improve participation of farmers.

ECF immunisation by ITM is reported to be better option than the traditional vector control strategy by use of acaricides in many ways including economic and intangible benefits (Martins *et al.* 2010).It is also a strategy that seems to overcome environmental problems such as pollution and biological challenges such as development of resistance by parasites and vectors. It is expected to see a reduction in acaricide use on immunised animalsthan in non-immunised animals (Mukhebi and Perry, 1992). This was not the case in Mazabuka district where, immunisation against ECF did not influence the rate of acaricide application. This could be due to occurrence of other tick-borne disease and perceived affordability of the acaricides. Therefore, it may be food for thought to start considering development of ITM for TBDs rather that sole focus on ECF because these diseases may have low mortality rate but substantial effect on production and they may necessitate use of acaricides.

CONCLUSION

Success of ECF immunisation campaign depends on among other things, participation of cattle keepers. Farmers participation in Mazabuka district seem to be influenced by importance of the exercise to livelihood of farmers and the outcome of immunisation. The latter is influenced by, among other factors, farmers satisfaction with

immunisation process and improvement in production through reduction of mortalities. Therefore, improvement in service delivery quality and monitoring of post immunisation outcome can lead to increased participation of farmers in immunisation campaigns.Removal of subsidies for ECF vaccinations requires further investigations before it is attempted.

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