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24 **Transmission dynamics of lumpy skin disease in Ethiopia**

25

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48 Running title: Lumpy skin disease transmission dynamics

49 **Summary**

50 Lumpy skin disease (LSD) is a severe disease of cattle caused by a *Capripoxvirus* and often
51 caused epidemics in Ethiopia and many other countries. This study was undertaken to
52 quantify the transmission between animals and to estimate the infection reproduction ratio in a
53 predominantly mixed crop-livestock system and in intensive commercial herd types. The
54 transmission parameters were based on a SIR epidemic model with environmental
55 transmission and estimated using generalized linear models. The transmission parameters
56 were estimated using a survival rate of infectious virus in the environment equal to 0.325 per
57 day, a value based on the best fitting statistical model. The transmission rate parameter
58 between animals was 0.072 (95% CI: 0.068-0.076) per day in the crop-livestock production
59 system, whereas this transmission rate in intensive production system was 0.076 (95% CI:
60 0.068-0.085) per day. The reproduction ratio (R) of LSD between animals in the crop-
61 livestock production system was 1.07, whereas it was 1.09 between animals in the intensive
62 production system. The calculated R provides a baseline against which various control options
63 can be assessed for efficacy.

64 **Key words:** Cattle, Ethiopia, LSD, Transmission, Reproduction ratio

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73 **1. Introduction**

74 Lumpy skin disease (LSD) is a severe viral disease of cattle, which often occurs as regional
75 epidemics within a larger area in which it is endemic. It is caused by *Lumpy skin disease virus*
76 (LSDV) which is of the genus *Capripoxvirus* of family *Poxviridae*. LSDV is one of the most
77 important animal poxviruses because of the serious economic consequences in cattle [1, 2].

78 The disease is characterized by lachrymation, fever, nodular lesions on the skin and mucosal
79 surfaces, lymph node enlargement, inflammatory and oedematous swelling of the legs and
80 lameness [1, 3].

81
82 The disease was reported for the first time in Zambia in 1929 and was confined to Africa until
83 an outbreak occurred in Israel in 1989 [1]. However, currently, the disease is found in most
84 African and Middle East countries and recently it has spread to eastern and south eastern
85 European countries. LSDV is clearly on the move in expanding its territory and increasingly
86 becoming a risk for other Asian and European countries [4].

87
88 Though the mechanism of LSDV transmission has not yet been clearly established, it is
89 hypothesized that the main mode of transmission of LSDV is via blood feeding arthropods
90 [5]. Experimentally, female *Aedes aegypti* mosquitoes have been shown to transmit LSDV
91 mechanically from infected to susceptible cattle [6]. The potential role of ixodid ticks in
92 transmission of LSDV has also been demonstrated in transmission studies including
93 mechanical transmission between cattle for *Amblyomma hebraeum* and *Rhipicephalus*
94 *appendiculatus*, trans-stadial transmission for *A. hebraeum*, and transovarial transmission for
95 *Rhipicephalus (Boophilus) decoloratus* [7-11]. Transmission of LSDV between infected and
96 susceptible animals by direct contact is considered to be inefficient [5, 12].

97

98 Data from infectious disease outbreaks are usually incomplete and highly dependent.
99 Incomplete because the infection process is only partially observable, i.e. not all cases may be
100 included due to under-reporting or because of asymptomatic cases, the number of susceptible
101 animals may not be known exactly, individuals who enter or leave the study population may
102 not be recorded accurately, there may be misdiagnosis of cases and flaws in data collection.
103 Data such as daily or weekly case numbers are obviously dependent [13, 14]. However,
104 transmission under field conditions can be estimated from the number of infections that
105 occurred during the study period or at certain intervals by mathematical modelling using
106 exactly that dependence [15, 16].

107

108 One parameter often used to characterize transmission is the basic reproduction ratio (R_0) with
109 the effective reproduction ratio (R_e) being the parameter for the transmission after
110 intervention. R_0 is defined as the average number of secondary infections caused by one
111 typical infectious individual in a fully susceptible population during its entire infectious
112 period [17], whereas R_e reflects the transmission parameter in a partially susceptible
113 (previously exposed or vaccinated) population [18]. The reproduction ratio (R) is frequently
114 used to describe the behaviour of transmission just after introduction of a disease. Whether an
115 outbreak spreads or dies out depends on whether the reproduction ratio is greater than, or less
116 than, 1 respectively. If R exceeds 1, a typical (i.e. average) infected animal infects on average
117 more than one susceptible animal, and thus it may cause a major outbreak, while if R is
118 smaller than 1 the disease will die out or it will at most produce a minor outbreak [16, 19].

119

120 Despite a large number of LSD outbreaks in many African and Middle East countries, its
121 dynamics are not well studied. Only one study, undertaken by Magori-Cohen et al. [12] in a
122 dairy herd of Israel, reports an estimate for the reproduction ratio of LSDV ($R_0 = 15.7$).

123 Therefore, the current study was undertaken with the objectives to better understand the
124 LSDV outbreak dynamics and to quantify the transmission rate parameter and the
125 reproduction ratio between animals.

126

127 **2. Materials and Methods**

128

129 **2.1. Study area, farms and animals contact patterns**

130

131 The study was carried out from 28 April 2014 to 1 February 2015 in the central and north-
132 western parts of Ethiopia. In the north-western part, it involves the cattle population in Mota
133 town and parts of the surrounding five Kebeles (Kebele is the smallest administrative unit in
134 Ethiopia covering an approximate area of 53 km²) in Hulet Ejju Enessie district, and
135 Debremarkos University dairy farm in Gozamn district. In the central part, the following
136 herds were enrolled: Selale Dairy Development Private Limited Company (Selale Dairy Dev't
137 PLC) in Wuchale district, Aser Dev't PLC in Sululta district, Ambo University dairy farm in
138 Ambo district, Holeta agricultural research centre farm (Holeta A.R.C) and Holeta special
139 cattle breeding centre (Holeta S.C.B.C) in Welmera district, Selam children village dairy farm
140 in Addis Ababa and Jenesis dairy farm in Ada'a district (Figure 1). Mota area (Mota town and
141 parts of the surrounding five Kebeles) covers an area of about five km radius. The production
142 system in the Mota area is mainly mixed crop-livestock while the other herds were
143 commercial dairy herds. Most of the animals in the mixed crop-livestock type of herds were
144 of local Zebu breed whilst the intensive herds consisted of Holstein-Zebu cross. Farms were
145 categorized into small (<10 cattle), medium (10-50 cattle), large (51-300 cattle), very large
146 (301-700 cattle) and extra-large (>700 cattle) based on the number of cattle they comprised.

147 The cattle contact network depends on a number of factors including housing system, size and
148 nature of grazing lands, water points, cattle density, and frequency and duration of contacts.
149 This study was undertaken at the family herd (group of animals owned by a family for
150 subsistence) and commercial farm (group of animals owned by a private or public
151 organization for commercial purpose) levels. All smallholder herds enrolled in the study were
152 in the Mota area, but the intensive commercial farms were located in different areas. Since the
153 smallholder herds in the subsistence crop-livestock system (Mota area) are managed
154 extensively, they regularly mixed at shared pastures and watering points so that they had to be
155 considered as one epidemiological unit. Animals in the intensive commercial farms, however,
156 did not have direct contact with animals in other farms in their surroundings and most of them
157 were located in districts far apart from each other.

158

159 **2.2. Period of the epidemic**

160

161 To assess the association between LSD epidemics and the season of the outbreak (which has a
162 strong relation with arthropod dynamics), the outbreak duration was categorized into three
163 periods, Belg (period 1), Kiremt (period 2) and Bega (period 3) following the meteorological
164 seasons of Ethiopia. Belg is a short rainy period from February to May over much of the
165 Belg-growing areas. However, over the north-western parts of the country (where Mota area
166 is located) this season is predominantly dry except for the month of May. Kiremt is the period
167 from June to September; it is the main rainy season in which the major food crops of the
168 country are produced. The magnitude of rainfall during Kiremt is higher as compared to the
169 other seasons for many parts of the country. Bega is the period from October to January. It is
170 normally a dry season characterized by cool nights and hot days over various parts of the
171 country [20].

172

173 **2.3. Infection status of animals**

174

175 Herds were visited every week to check whether or not animals showing symptoms of LSD
176 were present. If so, the infection chain within the herd was monitored by visiting the affected
177 herd twice a week throughout the study period and the LSD status (susceptible, infected or
178 recovered) of all animals was determined. At the start of the study all cattle were assumed to be
179 susceptible. The start of the infectious period was considered to be the day following that on
180 which an animal was first reported with clinical signs of LSD. Infected animals were assumed
181 to stay infectious on average for 10 days taking the duration of viraemia as a proxy for period
182 of infectivity [5, 21, 22]. An infected animal becomes most infective during the viraemic phase
183 of the disease because the amount of virus in various body tissues and secretions and excretions
184 of the animal become the highest in this phase [22]. Animals that died before the infectious
185 period was completed were considered infectious for the days they lived after being considered
186 infectious.

187

188 The contribution of environment (E) to the transmission of LSDV was established by
189 determining a per day survival rate of LSD virus shed into the environment by infected
190 animals. This was done by fitting a GLM model to the collected data by varying the survival
191 rate from 0.1 to 0.9 and selecting the best fitting model with the lowest AIC value.

192

193 Nodular samples were collected from few affected cattle in each herd to confirm the outbreak
194 by using conventional and snapback real-time PCR (polymerase chain reaction) techniques
195 following the procedure described by Gelaye et al. [23].

196

197 **2.4. Estimation of the transmission parameters**

198 The transmission parameters were estimated based on a SIR epidemic model in which
199 individuals are either susceptible (S), infected and infectious (I) or recovered and immune or
200 dead (R). During the study, the numbers of I and S observed in each herd were recorded at the
201 start of each observation interval. Animals were registered as a new case (C) on the date they
202 were reported with LSD and as infectious (I) on the next day. Transmission of LSDV between
203 animals has been estimated from the relationship between the number of infectious animals at
204 the start of the time interval and the number of newly infected animals at the end of the time
205 interval. Every new infection is related to the number of animals that were infectious at the
206 time of infection.

207

208 The transmission parameters were estimated by a generalized linear model (GLM) [24-27].
209 The transmission dynamics of LSD between individuals are described by the change in the
210 number of susceptible (S), infectious (I), and recovered (R) animals. Susceptible cattle
211 become infected with a rate of $\beta \cdot S_t \cdot (I_t + E_t) / N_t$. Here, β is the transmission rate which can be
212 interpreted as the average number of new infections caused by a typical infectious animal in a
213 fully susceptible population per unit of time, S_t is the number of susceptible animals, I_t the
214 number of infectious animals, E_t contribution of the environment to the transmission, and N_t
215 is the total number of animals at time t , and they are assessed at the start of each observation
216 period. The number of infectious contacts encountered by one individual in a period of length
217 Δt follows a Poisson distribution with parameter $(\beta \cdot (I_t + E_t) / N_t \cdot \Delta t)$. Hence, the probability
218 of a susceptible animal escaping infection, during a period Δt is $e^{-\beta \cdot \Delta t \cdot (I_t + E_t) / N_t}$, and thus the
219 probability to become infected is $1 - e^{-\beta \cdot \Delta t \cdot (I_t + E_t) / N_t}$. This implies that the number of new cases
220 (C) in a period Δt follows a binomial distribution. Consequently, the relation between the
221 expected number of cases per unit of time $E(C)$, and I_t , E_t , N_t , β , and S_t can be formulated as

222 $E(C_t) = S_t \cdot (1 - e^{-\beta \cdot \Delta t \cdot (I_t + E_t) / N_t})$. The transmission parameter β ($\beta = e^b$, where b is the regression
223 coefficient of the intercept of the model) was estimated using a GLM with a complementary-
224 log-log link function and $\log\left(\Delta t \cdot \frac{I_t + E_t}{N_t}\right)$ as offset. Finally, we obtained R by multiplying β
225 with the average length of the infectious period [19, 24, 27] times a factor of $(1-E)^{-1}$ which
226 incorporates the environmental contribution.

227

228 The Chi-square test was used to test the association of morbidity and mortality with
229 production systems and GLM to compare transmission rates between the three meteorological
230 periods, production systems and herd sizes.

231

232 All analyses were carried out in Stata 14.

233

234 **3. Results**

235

236 **3.1. Descriptive statistics**

237

238 During the study period, a total of 14,319 individual animals from 2,446 herds were followed
239 for LSD occurrence. 12,509 animals (in 2,438 herds) were kept in the crop-livestock system
240 and 1,810 animals (in 8 herds) in the intensive production system (Table 1).

241

242 The number of animals and herds affected, morbidity and mortality due to LSD per
243 production system are indicated in Table 1. The morbidity was significantly higher in the
244 intensive (17.5%) compared to the crop-livestock (10.1%) system. The mortality was also
245 significantly higher in the intensive (4.0%) than in the crop-livestock (0.7%) system (Table
246 1).

247

248 In the Mota area, the LSD outbreak started at the end of April 2014 but in the other study
249 farms the outbreak started later and continued until the first week of February 2015. The
250 epidemic curve of the LSD outbreak in the Mota area is presented in Figure 2.

251

252 3.2. **Transmission of LSD between animals**

253

254 The contribution of the environment to the transmission (E) and the number of C, I and S
255 animals in the Mota area are listed for each day of the epidemic (Supplementary Table S1).
256 The transmission rate parameter between animals in the dominantly subsistent crop-livestock
257 production system was 0.072 (95% CI: 0.068-0.076) per day (Table 2) whereas in the
258 intensive production system it was 0.076 (0.068-0.085) per day (Table 3). The survival rate of
259 infectious LSD virus in the environment was estimated as 0.325 per day based on the best
260 fitting statistical model and this value was used to account for the indirect transmission
261 (excluding the immediate or direct transmission) of the virus. The average LSD infectious
262 periods for animals are indicated in Table 2 and 3 for both production systems.

263

264 Based on the survival rate of LSDV in the environment, the multiplication factor of R was
265 1.5. Then a reproduction ratio of 1.07 between animals was calculated in the crop-livestock
266 production system in the Mota area (Table 2). R values between animals vary from 0.90 (Aser
267 dairy farm) to 1.15 (Ambo university) in the eight intensive farms while the overall R value
268 for intensive dairy farms was 1.09 (Table 3). Major outbreaks have been observed in Ambo
269 University, Holeta S.C.B.C, Holeta A.R.C, Selale Dairy Dev't PLC, Selam children village
270 dairy herds and Mota area (Table 3, Supplementary Table S2).

271 Transmission parameter rates (β) between animals for subsistence crop-livestock production
272 system in the Mota area showed significant differences between period two and three (P
273 <0.05) (Table 2). However, the transmission rates did not significantly differ between
274 production systems and herd sizes.

275

276 **4. Discussion**

277

278 The 10.1% and 17.5% animal level morbidity of LSD reported in the current study in the
279 subsistence crop-livestock production system and intensive system, respectively, are within
280 the range of what has been reported in previous works [1, 28]. Similarly, the mortality was
281 higher in the intensive production system than in the crop-livestock system. These significant
282 differences in morbidity and mortality between animals in the two systems might be explained
283 by the breed of cattle raised in the two systems. In the intensive system, Holstein-Friesian
284 local cross was the dominant breed which is more susceptible and more severely affected by
285 LSD than the local Zebu breed [1, 29], which is the breed commonly found in the crop-
286 livestock production system. The other reason might be related to the way we calculated the
287 morbidity and mortality in both systems. In the crop-livestock system, all animals in the Mota
288 area whether or not they were within an infected herd or not, were included in the
289 denominator, whereas in the intensive system only the number of animals in infected herds
290 were in the denominator to calculate the morbidity and mortality.

291

292 The infectious period and survival of the virus in the environment are important parameters in
293 estimating the reproduction ratio but these parameters were not reported in any of the
294 previous studies. However, information about these parameters is essential for formulating

295 appropriate prevention and control strategies for LSD. In this study too we did not estimate
296 the infectious period of an infected animal and the survival rate of the virus in the
297 environment because the study set up did not allow us to do that; instead we parametrized the
298 infectious period from information obtained in the literature and the survival rate by searching
299 for the best fitting model. We set the infectious period to 10 days for an infected animal by
300 taking into account the duration of virus isolation in blood for 10-12 days [5, 21].
301 Furthermore, there is no clear information when infected animals become infectious, which is
302 important to know for the quantification of transmission. Infectiousness may start before or
303 after the onset of clinical disease, but for this study we set the start of the infectious period as
304 24 h after the onset of the disease considering that LSDV isolation from blood and skin
305 samples were achieved in most of the cases after the affected animals showed fever [21].
306 Regarding the survival rate of the virus in the environment, literature indicates that the virus
307 survives in air-dried hides for at least 18 days, in necrotic skin nodules for up to 33 days or
308 longer, and for up to 35 days in desiccated crust [30], but it is not clear whether the viruses
309 surviving in these foci contribute to the transmission of LSD. Taking this information into
310 consideration we fitted a model (by selecting the best fitting model) to our data and found a
311 survival rate of 0.325 per day, which was used in the offset to incorporate the contribution of
312 environment to the transmission of LSDV. The implication of this survival rate is that the
313 infectivity is increased by almost 50%.

314

315 To our knowledge, this is the first field study in Ethiopia in which transmission rate
316 parameters have been quantified. This knowledge is helpful to design sets of measures that
317 efficiently eliminate the virus. In the study, LSDV transmission was modelled by considering
318 it as direct transmission. It is widely believed that LSDV is transmitted from infected to
319 susceptible hosts indirectly through mechanical arthropod vectors, though the importance of

320 the different types of arthropod vectors in the transmission of LSD virus in field conditions is
321 not fully understood [5, 12]. If a blood feeding arthropod feeds briefly on viraemic cattle and
322 is interrupted, a subsequent immediate feeding on a second animal could result in virus
323 transmission. The virus does not replicate within the vector [31] which thus serves as a
324 passive carrier to transmit the disease. The vector in this case serves only as a bridge for the
325 transmission of LSDV from infected to susceptible cattle so that we did not incorporate the
326 vectors in the transmission model.

327

328 During the outbreak, LSDV was transmitted between animals with a rate of 0.072 per day in
329 the crop-livestock production system. The transmission chain from which specific infected
330 cattle to which susceptible cattle was not clearly identified due to the free movement and
331 mixing up of animals in the area and mechanical transmission of the disease by arthropods
332 vectors. Hence, the transmission rate between animals was calculated by considering the
333 cattle population in the area as one population.

334

335 In the Mota area, the transmission rate of LSD was also estimated for different time periods
336 and the results indicate a significant difference in daily transmission rates between periods.
337 The per day transmission rate between animals was higher at the beginning of the outbreak (in
338 period 1 and 2 compared to period 3). This was expected, because during these periods the
339 susceptible population was not yet depleted and no specific measures were taken to reduce
340 transmission. This result indicates that starting implementation of control measures at early
341 stage of the outbreak is necessary to halt the spread of the disease. We did not assess the
342 periodic variation of transmission rate in farms of intensive production system due to the fact
343 that the outbreaks in those farms were relatively short and it was not convenient to divide the
344 time into different periods as in most occasions the outbreak fell in one period.

345

346 In this study, we estimated an R value of 1.07 between animals in the crop-livestock area. The
347 R values within the intensive farms were also in the range of 0.90 to 1.15 with an overall
348 value of 1.09. These R values are low compared with the R value of 15.7 reported for indirect
349 transmission within a commercial dairy farm in Israel [12]. The difference might be explained
350 by the method how R is calculated, different study population, the environmental difference
351 and the production set up.

352

353 Knowledge of within herd transmission is necessary to assess the effectiveness of intervention
354 measures and to design effective monitoring programmes [32-34]. In this study, we estimated
355 that R was greater than 1 between animals in the dominantly crop-livestock system and in
356 some farms of the intensive production system. This sheds light on LSDV transmission and
357 further work should focus on the effect of control measures that add to bring R below the
358 threshold level. LSD control will be achieved if both reproduction ratios, among animals and
359 between herds are less than 1; and also if R among animals is greater than 1, but R, between
360 herds is below 1. Infections with low R values are less difficult to control than those with a
361 high R value [34]. Our estimates of R provides a baseline against which various control
362 options can be assessed for efficacy. In general, from this study it can be concluded that
363 transmission of LSDV between animals in Ethiopia is low.

364

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371 **Conflict of interest**

372 None

373

374 **5. References**

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459 island with a BHV1 control programme. *Epidemiology and Infection* 2003; **130**: 541-
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463 Table 1. LSD morbidity and mortality in subsistence crop-livestock and intensive commercial farms.

Area/Farm	Dominant Production system	No. of total herds	No. of total animals	No. of affected herds	No. of infected animals	Morbidity in %	No. died	Mortality in %
Mota area ^a	crop-livestock	2438	12509	841	1266	10.12	81	0.65
Ambo University	Intensive	1	86	1	24	27.91	6	6.98
Aser Dev't PLC	Intensive	1	50	1	5	10.00	0	0
Debreworkos University	Intensive	1	42	1	6	14.29	0	0
Holeta S.C.B.C	Intensive	1	429	1	88	20.51	19	4.43
Holeta A.R.C	Intensive	1	623	1	84	13.48	6	0.96
Jenesis dairy farm	Intensive	1	204	1	8	3.92	0	0
Selale Dairy Dev't PLC	Intensive	1	330	1	93	28.18	40	12.12
Selam Children village farm	Intensive	1	46	1	9	19.57	2	4.35
Intensive subtotal		8	1810	8	317	17.51	73	4.03

464 ^a All herds and animals at risk considered
 465 χ^2 (1) = 87.89, P = 0.000 for differences in morbidity between animals in crop-livestock and intensive systems
 466 χ^2 (1) = 170.35, P = 0.000 for differences in mortality between animals in crop-livestock and intensive systems

467 Table 2. Transmission parameters of LSD virus between animals by meteorological period in dominantly crop-livestock system (Mota area),
 468 Ethiopia, during the 2014 epidemic.

Transmission	Period	No. of weeks	No. of cases	β (95% CI) per day	P-value	Average inf. period in days	R^a (95% CI)
Between animals	1 (18-22 ^b)	5	12	0.077 (0.043 - 0.139)	0.315	8.25	0.95 (0.53-1.72)
	2 (23-39)	17	887	0.080 (0.075 - 0.085)	0.000	9.03	1.08 (1.02-1.15)
	3 (40-47)	8	367	0.057 (0.051 - 0.063)	Ref	12.11	1.04 (0.93-1.14)
Overall		30	1266	0.072 (0.068 - 0.076)		9.92	1.07 (1.01-1.13)

469 ^aR is obtained after multiplying the product of β and infectious period by a factor of 1.5 which is a sum of the infectivity of the infected animal
 470 (1) and infectivity of the virus accumulated in the environment (0.5) at a particular date of the epidemic.

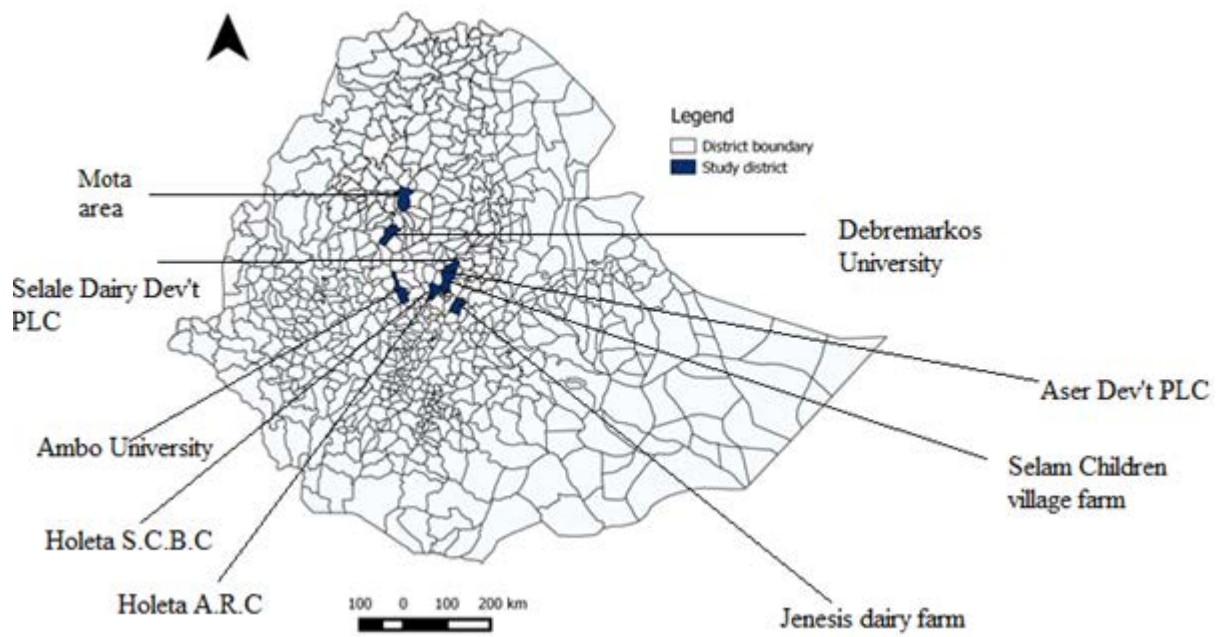
471 ^bWeek number.

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483 Table 3. Transmission parameters and reproduction ratios of LSD virus within eight intensive dairy herds and Mota area during the 2014/15
 484 epidemic.

Area/Farm	Production system	No. of animals	No. of cases	Outbreak dur. in weeks	β (95% CI) per day	Average Inf. period in days	R^a (95% CI)
Ambo University	Intensive	86	24	8	0.086 (0.057-0.130)	8.92	1.15 (0.76-1.74)
Aser Dev't PLC	Intensive	50	5	4	0.060 (0.022-0.159)	10	0.90 (0.33-2.39)
Debremarkos University	Intensive	42	6	4	0.064 (0.027-0.154)	10	0.96 (0.41-2.31)
Holeta S.C.B.C	Intensive	429	88	15	0.078 (0.063-0.096)	9.51	1.11 (0.90-1.37)
Holeta A.R.C	Intensive	623	84	17	0.071 (0.057-0.088)	9.96	1.06 (0.85-1.31)
Jenesis dairy farm	Intensive	204	8	8	0.061 (0.029-0.128)	10	0.92 (0.44-1.92)
Selale Dairy Dev't PLC	Intensive	330	93	21	0.082 (0.066-0.100)	9.24	1.14 (0.91-1.39)
Selam Children village farm	Intensive	46	9	7	0.068 (0.034-0.137)	10	1.02 (0.51-2.06)
Intensive total		1810	317	84	0.076 (0.068-0.085)	9.55	1.09 (0.97-1.22)
Mota area	Crop-livestock	12,509	1266	30	0.072 (0.068-0.076)	9.92	1.07 (1.01-1.13)
Overall		14,319	1583	114	0.073 (0.069-0.076)	9.84	1.08 (1.02-1.12)

485 ^aR is obtained after multiplying the product of β and infectious period by a factor of 1.5, a sum of infectivity of the infected animal (1) and the
 486 infectivity of the virus accumulated in the environment (0.5) at a particular date of the epidemic.



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488 Figure 1. Map of Ethiopia showing LSD transmission study districts.

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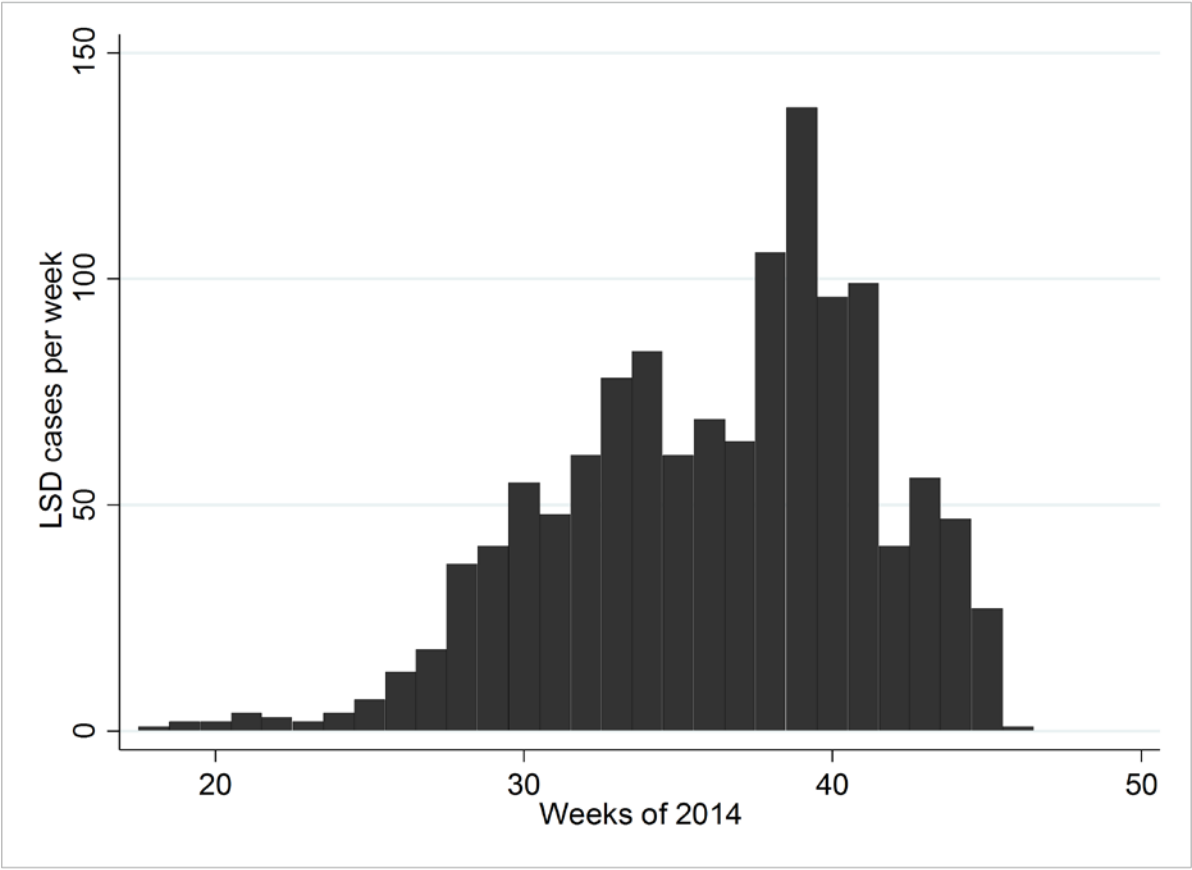
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504 Figure 2. Epidemic curve of lumpy skin disease in Mota area, Ethiopia, in 2014.

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