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Epidemiology of Lumpy Skin Disease in Egypt between 2006 and 2018

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ABSTRACT

Lumpy Skin Disease (LSD) is a notifiable vector-borne disease transmitted by blood-feeding insects affecting cattle populations. LSD is a severe disease that is leading to economic losses. In this study, we displayed the prevalence of LSD in Egypt through retrospective and survey studies to point out the possible hazards of this serious disease. The 2006–2018 passive surveillance data were obtained from *OIE-Wahis*. A survey was conducted on 326 cattle, collected from 40 villages in 2017, using a structured questionnaire. Between 2006 and 2018, a total of 577 positive LSD outbreaks were reported. For spatial distribution, the Delta region showed the highest significant prevalence of 88% in the 2006 outbreak. Afterwards, Upper Egypt recorded the highest LSD prevalence between 2014 and 2018. The temporal distribution showed an alternative seasonal prevalence of LSD. In the cross-sectional study, the Delta had the highest prevalence, followed by Upper Egypt. Between the seasons, autumn had the highest prevalence followed by winter. Animals over the age of two years had the highest prevalence of risk factors. Dairy animals had a high significant prevalence. Housing animals in the open, the presence of farms near markets and repeated visits to markets, all had a high prevalence. The abundance of biting-flies significantly increased the prevalence. Almost all of the farmers were significantly unaware of the disease. The absence of periodic cleaning, animal isolation, and proper carcass disposal, all significantly increased LSD prevalence especially in unvaccinated animals. In conclusion, the retrospective and cross-sectional studies showed that LSD is an endemic disease with both spatial and temporal distributions. In addition, the survey pointed out the husbandry and biosecurity breaches that magnify LSD prevalence. Therefore, raising disease awareness and applying strategic prevention and control measures are the practical pillars against LSD.

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INTRODUCTION

Lumpy Skin Disease (LSD) is a notifiable vector-borne disease transmitted by blood-feeding insects **(Carn and Kitching, 1995)**. LSD results in economic losses **(Gezahegn *et al*., 2013)**. Lumpy skin disease virus (LSDV) is one of the species of *capripoxviruses* in the family *Poxviridae*, infecting cattle of all ages and breeds **(Murphy *et al*., 1999; Babiuk *et al*., 2008).** LSDV is very resistant to inactivation. It can survive for a very long time at room temperature, notably in dried scabs for up to 35 days and in air-dried hides for at least 18 days. Presently, LSD presents a serious endemic risk to populations of cattle throughout the Middle East and Africa (**Kumar, 2011**). The morbidity ranges between 3–85%, while mortality ranges from 1–40%; this is due to cattle having different genetic susceptibilities (**AL-Sabaawy *et al*., 2020)**. In addition, strain severity, and vector abundance had a strong effect on morbidity and mortality rates **(Gari *et al*., 2010).** Decreased milk production, loss of animals, reproductive problems, emaciation, and hide damage are the major negative economic impacts of LSD **(CFSPH, 2008).**

The disease spreads its borders to many locations worldwide with various ecological and climatic conditions **(Davies, 1991; EFSA, 2019)**. Rainy seasons and cow grazing regions along water surfaces are linked to outbreaks of LSD. Also, herd size and immunity were connected to the development of disease. Livestock management techniques, such as new animals' introduction, mixing cattle in drinking and grazing areas, and lack of control over free roaming, may ease disease spread. **(Zelalem *et al*.,**

2019). It's likely that tainted food and water are sources of LSD infection **(Al-Salihi and Hassan, 2015).** Mass vaccination is the most efficient technique of disease management, although it is possible to separate and kill diseased animals **(Hailu *et al*., 2015)**.

LSD was first reported in Egypt in 1988 with little or no manifestation of clinical disease. Most Egyptian governorates were affected. The disease reappeared in 1989 and had a severe effect as 1449 animals died (**Salib and Osman, 2011**). Egypt became re-infected with LSDV in 2006 after importing cattle from East Africa **(Wainwright *et al*., 2013)**. All age categories of Egyptian cattle were affected with serious outcomes as the disease spread to various governorates (**Salib and Osman, 2011**). The current study consisted of a retrospective study to describe the occurrences of LSD outbreaks in Egypt between 2006 and 2018 and a survey study to determine the related hazards.

MATERIALS AND METHODS

Retrospective study

The country's passive surveillance data were collected from **(*OIE-WAHIS*)** dashboard. Relevant data such as the disease (LSD) occurring years and different districts affected by the disease were collected between 2006 and 2018. Egypt spatial distribution included 4 regions; Upper Egypt (Giza, Cairo, Fayoum, Banisuif, Menia, Sohag, Assuit, Qena, Louxer, Aswan), Delta (Qaliobya, Monofya, Sharkya, Gharbya, Dakahlia, Domyat, Kaferelshikh, Alexandria), Canal (Suez, Portsaid, Ismailia) and Desert (Red Sea, New Valley, Matrouh)**.** In addition, the temporal distribution of LSD in different seasons (spring, autumn, summer and winter) was also collected.

Cross sectional survey

A survey was conducted between January and December 2017. The minimum sample size was determined by the formula $N = (2 / E)^2 P(1-P)$, where E is the absolute precision and P is the previous seroprevalence (**Thrusfield, 2018**) with 5% absolute precision and previous seroprevalence of 20%, as reported by the OIE in 2016 **(*OIE-WAHIS*)** site. Accordingly, 326 sample size for the study was collected from 40 villages in 17 governorates of Egypt. The owners were interviewed as their animals showing clinical signs of LSD (Lacrimation, skin lesions drop of milk and fever) as described by **(*OIE*, 2010)** by using a structured questionnaire. The questionnaire contained basic data as (governorate, village, and date of visit, total number of animals and number of animals showed clinical signs). A risk practice table was established to identify husbandry system (type of housing, type of drinking and grazing, isolation sick animals, markets distances). Smallholder farmer responses to general information, knowledge, attitudes, and practices as (visits of markets and owner movement, vaccination of animals) were also collected **(Gari *et al*., 2010).**

Statistical analysis

Analyses were performed using SPSS software® version 20 (IBM, USA). The Chi-square or Fisher's exact test was used to determine differences in prevalence. $P < 0.05$ was considered significant.

RESULTS

Retrospective study

The total LSD outbreaks were showed in Fig 1. The total positive LSD notified outbreaks reached 577 between 2006 and 2018**.** The disease disappeared and returned in 2012 with only one notification. Since 2012, LSD has occurred every year with endemic surges of 48 notifications in 2015 and 45 notifications in both 2014 and 2018.

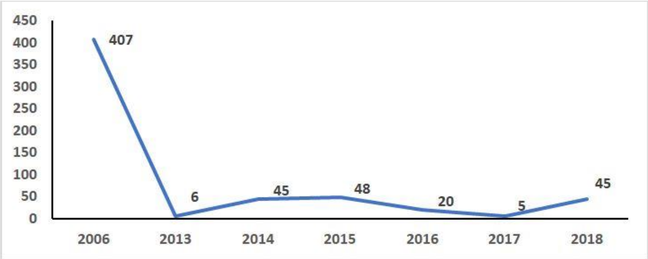

Fig. 1: LSD notifications in Egypt during 2006-2018.

Spatial distribution of LSD in Egypt (Upper Egypt, Delta, Suez Canal, and Desert regions) was illustrated in (Table 1**)**. In general, Delta region showed the highest confirmed epi-units due to the 358 (88%) recorded notifications in 2006 outbreak. After 2006 outbreak, Upper Egypt recorded the highest LSD prevalence between 2014 and 2018.

Temporal distribution of LSD was described in (Table 2), the highest total recorded outbreaks per year were 407 in 2006 with 311 notifications in the summer followed by 82 reported in spring. After 2006, within year, autumn was the season of highest reported LSD outbreak prevalence ranged between 40% and 83.3% in 2013, 2014, 2016 and 2017. In 2015, winter had the highest prevalence of 39.6% followed by spring with 29.2% LSD prevalence. In 2018, summer returned to have the highest prevalence record of 57.8%.

Cross sectional study

The prevalence of clinical LSD cases from January to December 2017 was reported in Fig 2. From total 326 examined cattle, only 95 cases were clinically manifested with prevalence 29.14% in the investigated 17 governorates of Egypt. The Delta region had the highest prevalence of 53%. The three main governorates were Dakahlya 15%, Kafr el-sheikh 14% and Sharquia 10%. The prevalence of Upper Egypt region was 39%. The two main governorates were Quena 16% and Fayom 7%. LSD temporal prevalence was showed in Fig 3. The highest prevalence of 42% was recorded in autumn, followed by winter 20%. Both spring and summer had the same prevalence of 19%.

Table 1: Spatial Distribution of LSD in Egypt (4 regions) during 2006 -2018

Year		Region				Total
		lower Egypt	Upper Egypt	Suez Canal	Desert	
2006	Count	358	36	8	5	407
	%	88.0%	8.8%	2.0%	1.2%	
2012	Count	1	0	0	0	1
	%	100.0%	0.0%	0.0%	0.0%	
2013	Count	3	1	1	1	6
	%	50.0%	16.7%	16.7%	16.7%	
2014	Count	8	32	2	3	45
	%	17.8%	71.1%	4.4%	6.7%	
2015	Count	10	29	8	1	48
	%	20.8%	60.4%	16.7%	2.1%	
2016	Count	8	12	0	0	20
	%	40.0%	60.0%	0.0%	0.0%	
2017	Count	0	4	1	0	5
	%	0.0%	80.0%	20.0%	0.0%	
2018	Count	20	24	1	0	45
	%	44.4%	53.3%	2.2%	0.0%	
Total	Count	408	138	21	10	577
	%	70.7%	23.9%	3.6%	1.7%	

Table 2: Temporal Distribution of LSD in Egypt during 2006-2018:

Year		Season				Total
		Summer	Autumn	Winter	Spring	
2006	Count	311	0	14	82	407
	%	76.4%	0.0%	3.4%	20.1%	
2012	Count	1	0	0	0	1
	%	100.0%	0.0%	0.0%	0.0%	
2013	Count	0	5	0	1	6
	%	0.0%	83.3%	0.0%	16.7%	
2014	Count	6	33	3	3	45
	%	13.3%	73.3%	6.7%	6.7%	
2015	Count	13	2	19	14	48
	%	27.1%	4.2%	39.6%	29.2%	
2016	Count	7	8	1	4	20
	%	35.0%	40.0%	5.0%	20.0%	
2017	Count	1	3	1	0	5
	%	20.0%	60.0%	20.0%	0.0%	
2018	Count	26	10	3	6	45
	%	57.8%	22.2%	6.7%	13.3%	
Total	Count	365	61	41	110	577
	%	63.3%	10.6%	7.1%	19.1%	

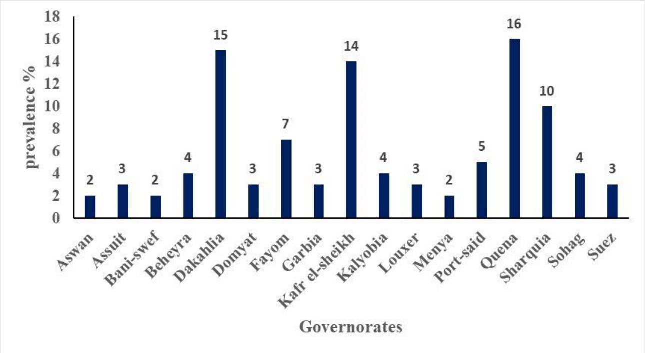

Fig. 2: Prevalence % of LSD in 17 governorates during 2017 (n = 95).

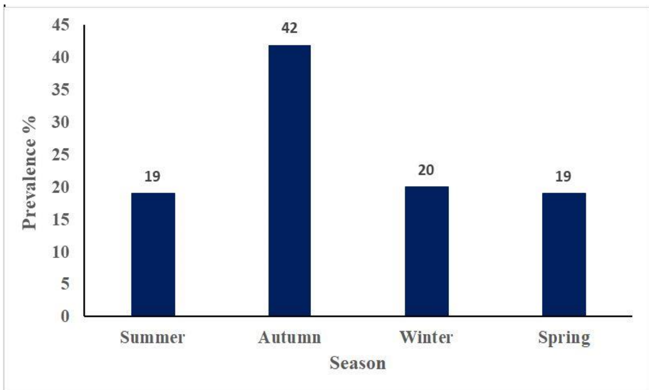

Fig. 3: Temporal prevalence% of LSD in 2017 .

Risk Factors

Effect of production factors on prevalence of LSD was clarified in Table 3. All age groups were affected but the age of more than two years showed significantly higher Prevalence of 86.4% (P≤ 0.004). In our study, the type of production recorded a significant increase of LSD prevalence in dairy animals 59.7% (P ≤0.02). Housing animals in the open significantly increased prevalence 70.5% (P≤0.001) compared to a closed system. Cows reared alone showed significant high prevalence 65% (P ≤.0.003) than cows mixed either with buffalo or sheep (species-specific disease). The presence of cattle farms near animal markets showed significant high LSD prevalence of 72.6% (P≤ 0.03). Repeated farmer's visits to markets significantly increased prevalence 75.7% (P≤ 0.02). The presence of biting-fly population significantly increased the prevalence 66.3% (P≤. 0.0001).

The practices of biosecurity within LSD infected farms were showed in Table 4. Almost all of farmers with LSD cases (94.7%) were significantly unaware about the disease (P≤0.01). The presence of unvaccinated animals increased prevalence 87.4% significantly (P≤0.03). Likewise, the absence of periodic cleaning of pen, animal isolation either diseased or new, and personnel hygiene, all of them had significant high prevalence of 97.9% (P≤ 0.004). Also, improper carcasses disposal by throwing in water canals significantly increased prevalence 89.5% (P≤0.02).

Table 3: Effect of production factors on prevalence % of LSD in different governorates (n=95)

Variable	Status	LSD clinical cases No.	LSD clinical cases Prevalence %	P-value
Age	< 2 years	13	13.6	0.004
	> 2 years	82	86.4	
Type of production	Dairy	91	59.7	0.02
	Fattening	4	40.3	
Housing	Open system	67	70.5	0.001
	Closed system	28	29.5	
Mixed rearing	Cow only	62	65	0.003
	Cows+buffalo	14	15	
	Cows+ sheep	19	20	
Market	Near	69	72.6	0.03
	Away	26	27.4	
Market visit	Visit	72	75.7	0.02
	Not visit	23	24.2	
Possible source of transmission	Neighbor	25	26.3	0.001
	Fly	63	66.3	
	Water canals	7	7.4	

Table 4: Biosecurity procedures adopted in the infected farms with LSD in different governorates.

Variable	Status	LSD clinical cases No.	LSD clinical cases Prevalence %	P-value
disease Awareness	No	90	94.7	0.01
	Yes	5	5.3	
Vaccination	No	83	87.4	0.03
	Yes	12	12.6	
Cleaning pen periodically	No	93	97.9	0.004
	Yes	2	2.1	
Isolation of diseased animal	No	93	97.9	0.004
	Yes	2	2.1	
Personal hygiene	No	93	97.9	0.004
	Yes	2	2.1	
Carcass disposal	Throw	85	89.5	0.02
	Burry	10	10.5	

DISCUSSION

In this study, we displayed the prevalence of LSD in Egypt through retrospective and survey studies to point out the possible hazards of this serious livestock-threatening disease. In the retrospective study, during 2006–2018, the total number of positive LSD-notified outbreaks reached 577 with the highest recorded outbreaks per year being 407 (70.54%) in 2006**.** The recurrence of LSD in 2006 was caused by the import of infected cattle from East Africa, resulting in a high incidence and notification rate. The disease disappeared in 2011 and returned in 2012 with only one notification. The cause of the periodic disappearance of LSD could not be justified irrespective of ecological predisposing factors (**Tuppurainen *et al.*, 2017**). LSD has become endemic not only in Egypt, but also in the Middle East and Europe since 2012 (EFSA, 2019). Vectors and the movement of infected cattle are the main routes by which LSD spreads into uninfected areas. Hence, vaccination and restricting livestock movement are key control actions **(Davies, 1991; Radostits *et al.*, 2006).** For the spatial distribution of LSD in Egypt (Upper Egypt, Delta, Suez Canal, and Desert regions), the Delta region showed the highest confirmed epi-units due to the 358 (88%) recorded notifications in the 2006 outbreak. Geographically, the Delta region is considered one block (no borders between governorates) with a high census of animals and is famous for agriculture crops, especially rice, which provide good environmental conditions for the amplification and reproduction of biting flies (the risk factor). Between 2014 and 2018, Upper Egypt recorded the highest LSD prevalence.

Our results coincide with those of **Ochwo *et al.*, (2018),** as the seasonal peak of biting arthropods and humid weather conditions in Upper Egypt are strongly correlated with outbreaks of LSD**.** In terms of temporal distribution, summer 2006 had the most total recorded outbreaks per season. Summer in Egypt is characterised by high temperatures and high humidity, which is a suitable environment for the reproduction and spread of insects that transmit the disease. After 2006, within a year, autumn was the season of the highest reported LSD outbreak. Our results agree with **Ali *et al*. (1990),** who stated that the onset of the wet season followed by autumn is where the vectors are maintained and the virus is mechanically transmitted**.** In our study, the within-year alteration of the temporal prevalence of LSD between seasons may be attributed to the fact that there has never been a season without vectors in Egypt; thus, outbreaks can happen at any time of year and are not only restricted to hot, humid months. Furthermore, the presence of various watercourses and water ponds near cattle populations can influence the quantity of insect vectors **(Tuppurainen *et al.*, 2017).**

For the cross-sectional study, spatial distribution showed the Delta region to have the highest prevalence of 53%. This high prevalence may be due to the presence of immersed rice fields which help vector propagation and boost the disease's occurrence. This result was also agreed with **Gumbe,** (**2018**) who mentioned that the presence of collective water surfaces is a key risk factor that could accelerate the development of outbreaks. The prevalence of the Upper Egypt region was 39%. Upper Egypt has a high density of cattle accompanied by humid weather and open market conditions. As proposed by Ali et al., (1990; Tuppurainen and Oura, (2012)), these factors remained primarily related to the high LSD prevalence. For temporal distribution**,** the highest prevalence of 42% was recorded in the autumn, followed by winter at 20%. Our results matched those of **Kawther, (2008)** who observed a significant incidence of LSD in Egypt during winter (36.7%) and fall (25.6%) because of hostile situations during seasonal changes, unfavorable management conditions, and the importation of animals from other regions, particularly from Africa. LSD outbreaks are strongly correlated with the periodic rise of vectors during hot and humid weather **(Gari *et al.*, 2010).**

Cattle management practices, executed by livestock owners, contribute to the spread of LSD. In particular, the addition of new animals, the mixing of cattle at pasture and drinking areas, and the unrestricted transfer of animals. **(Zelalem *et al.*, 2019).** For LSD hazard identification, the effect of production factors on the prevalence of LSD in different governorates was investigated. All age groups were affected, but cattle older than two years old had a significantly higher prevalence**.** These results agree with **Molla *et al.*, (2018)** who reported age group ≥4 years as one of the significant factors associated with LSD status. Also, our results coincided with those of **Salib and Osman, (2011),** where all categories of Egyptian cattle were affected with severe outcomes. On the contrary, **Abera, (2015); Elhaig *et al.*,** (**2017**) observed no statistically significant association between the age groups in which they are equally exposed to risk, although the prevalence was higher in adult cattle. Also, **Tageldin *et al.*, (2014)** reported that young calves are more severely affected, even though LSD impacts all kinds and ages of cattle**.**

In our study, the type of production recorded a significant increase in LSD prevalence in dairy animals**.** These findings are consistent with **Hunter and Wallace (2001); OIE (2010); Tuppurainen and Oura (2012); Tageldin *et al.*, (2014)** who found that cows in the peak of lactation are more severely affected. In this study, keeping animals outside significantly increased the prevalence. These shaded animal pens are considered a suitable environment for insects that persist for up to six months in them **(Hailu *et al.*, 2015)**. The presence of cattle farms near animal markets, and repeated farmer's visits to markets showed a significantly high prevalence. These results agreed with **Molla *et al.*,** (**2018); Selim *et al.*, (2021)** who reported that animal contact and the addition of new animals to farms were among the significant risk factors associated with LSD outbreaks in some regions of Egypt like those recorded in Ethiopia. As a result, restricting animal movement reduces disease prevalence **(Tuppurainen and Oura, 2012).** LSDV can be mechanically transmitted by mosquitoes such as *Aedes aegypti* **(Chihota *et al.*, 2001; Chihota *et al.*, 2003; Tuppurainen and Oura, 2012)**.

In the present study, LSD prevalence was significantly higher in the presence of a biting-fly population. Therefore, LSD outbreaks typically happen during the wet season, when there is a high level of insect activity **(Quinn *et al.*, 2002; Zeynalova *et al.*, 2016).** LSDV was reported to be shed in all animal exudates and may survive inside the dropped scabs for several months **(Tuppurainen *et al.*, 2017; Sudhakar *et al.*, 2020)**. Long survival times have also been demonstrated in farm tools **(Gumbe, 2018).** In our study, biosecurity practises on LSD-infected farms revealed that almost all farmers were completely unaware of the disease. In addition, the presence of unvaccinated cattle increased the prevalence significantly. Our results agreed with those of **Coetzer *et al.*, (1994),** who said that the main hazards for LSD infection are the presence of susceptible animals and arthropod vectors. Equally, LSD outbreaks may occur because of an inadequate vaccination process or immunocompromised animals (**Molini *et al.*, 2017)**. In our study, we found that the absence of periodic cleaning of pens, lack of isolation of diseased or new animals and lack of personnel hygiene, all significantly increased the prevalence.

Also, improper carcass disposal by throwing them in water canals significantly increased the prevalence. These biosecurity breaches, with their significant high LSD prevalence, confirmed that all feasible strategies must be validated in order to stop the spread of LSD. These strategies include raising farmer awareness of biosecurity and LSDV, reducing vectors' density, regularly treating cattle with insect repellents, isolating sick cattle and avoiding communal grazing, restricting all cattle movement in affected areas, and developing a safe and effective LSD vaccine.

CONCLUSION

In this work, the retrospective and cross-sectional studies between 2006 and 2018 showed that LSD is an endemic disease in both the spatial and temporal distributions of Egypt. In addition, the survey pointed out the hygiene and biosecurity breaches that magnify LSD prevalence. Therefore, raising disease awareness and applying strategic prevention and control measures are the practical pillars against LSD.

Conflicts of interest

The authors declared no competing interests.

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