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The spatial and temporal distributions of lumpy skin disease virus in different Egyptian governorates from 2016 to 2020 followed by another descriptive study in two main risk governorates in Egypt.

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ABSTRACT

Lumpy skin disease (LSD) is a viral disease that affects breeding cattle flocks in Egypt, leading to significant economic losses. This study aimed to investigate the spatial and temporal distribution of LSD from 2016 to 2020 across different affected governorates in Egypt. The surveillance data were collected from the OIE-WAHIS website followed by a field investigation of LSD in two main risk governorates in Egypt. The obtained results showed a significant ($p< 0.05$) difference in LSD prevalence rate among Egypt governorates, with the highest prevalence rate recorded in Menofia Governorate at Delta. In addition, the highest prevalence rate was recorded in 2018 at (36%), while the lowest was in 2017 with (4%). Furthermore, the temporal distribution of LSD was the highest during the period from July to December (summer and autumn) with (16.2%) of LSD prevalence rate. On the other hand, our results of the descriptive study revealed that the percentages of clinically infected cattle were higher in Qalubia than in the Menofia Governorate. Finally, LSD is an endemic disease in Egypt that is present throughout the year in different governorates, with varying prevalence rates across seasons.

1. INTRODUCTION

Lumpy skin disease (LSD) is a serious transboundary pox viral disease affects cattle and is caused by the lumpy skin disease virus (LSDV) (Elhaig *et al.*, 2021). The original foci of LSD appeared in Zambia in 1929 so, LSD was considered as an endemic disease in the African areas. In the beginning, clinical signs of LSD were considered the consequence either of hypersensitivity to insect bites or poisoning. The same clinical signs occurred in Zimbabwe, Botswana, and South Africa between 1943 and 1945, where the infectious pattern of this disease was investigated in these outbreaks (Al-Salihi, 2014). LSD occurred as a panzootic disease, affecting eight million animals in South Africa. This disease became continuous until 1949 and caused severe economic losses (Diesel, 1949).

LSD appeared in East Africa in Kenya in 1957 and appeared in Sudan in 1972 (Ali and Obeid, 1977) also, appeared in West Africa in 1974. Moreover, it spread into Somalia in 1983 (Davies, 1991a&b). Also, the disease spread around the African region in 1984. It appeared in Madagascar and other countries in the Arab Gulf Peninsula and the Middle East (Al-Salihi, 2014).

The outbreaks of LSD appeared in the Middle East in Oman in 1984 (Kumar, 2011; Tageldin, 2014), Kuwait in 1986 (Shimshony and Economides, 2006), Egypt in 1988 (Salib and Osman, 2011; Ahmed and Amina Dessouki., 2013) and Israel in 1989 (Shimshony and Economides, 2006).

LSD was re-emerged again in Kuwait in 1991(Shimshony and Economides, 2006). The outbreaks of LSD first appeared in Bahrain in 1993 (Wainwright *et al*., 2013). It appeared in United Arab Emirates and Yemen in 2000. Also, it was identified in Mozambique, Mauritius, and Senegal in 2001 (Wainwright *et al*., 2013).

It re-emerged again in Bahrain in 2002 and 2003(Wainwright *et al*., 2013), in Israel in 2006 (Shimshony and Economides, 2006), also re-emerged in Egypt in 2006 (Salib and Osman, 2011; Ahmed and Amina Dessouki., 2013) and Oman in 2009 (Tageldin *et al.*, 2014).

Recently, LSD was identified in Turkey in October 2013 also, in Iran and Iraq in 2014 (Wainwright *et al.*, 2013). In Iran, the LSD had been reported for the first time in 2014. Subsequently, in August 2015, LSD was confirmed in the laboratories of Greece, and this disease was the first incursion into Europe (Tasioudi *et al.*, 2016). It was first identified in the North Caucasus of Russia in 2015, and the first outbreak in Russia appeared in Dagestan (Sprygin *et al.*, 2018).

In Egypt, LSD was introduced with cattle imported from Africa and kept at the station of local quarantine. It spread locally into and around Ismailia and Suez governorates in May 1988 (House *et al.*, 1990). Twenty-two out of twenty-six Egypt governorates were affected with LSD, then reappeared in the summer of 1989 and continued for five to six months. This epizootic showed a low morbidity rate (2%) due to the vaccination procedures that included nearly two million of cattle with a sheep pox vaccine. However,

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approximately 1449 cattle died. In the summer of 2006, LSD outbreak has invaded cattle in different regions of Egypt after the importation of infected animals from Ethiopia (Al-Salihi, 2014). The outbreaks reemerged again in many Egypt governorates, where all ages and both sexes of Egyptian animals were infected with serious and severe complications (Salib and Osman, 2011; Ahmed and Amina Dessouki., 2013).

The seasonal pattern of LSD occurrence has a higher prevalence during certain months and seasons (Gomo *et al.*, 2017). The prevalence rate of LSD tends to be low during the winter season and increases again with the onset of summer and spring (Gupta *et al.*, 2020).

Specific vectors of LSDV were not confirmed, but strong investigations support that the LSDV was mechanically transmitted via Aedes mosquitoes (Chihota *et al.*, 2001) and ticks (Tuppurainen *et al.*, 2011). LSD affects all cattle breeds and ages, but the young ages and cows in the peak of lactation were more severely infected (Tageldin *et al.*, 2014). LSD leads to significant economic losses in the livestock industry (Al-Salihi, 2014).

The objective of this study is determination the spatial and temporal distribution of LSD, wide spread of this disease in different governorates throughout the different seasons in Egypt.

2. MATERIAL AND METHODS

2.1. Retrospective study of LSD in Egypt from 2016 to 2020.
The spatial and temporal data of LSD in Egypt were obtained from the OIE-WAHIS website (https://www.woah.org/en/what-we-do/animal-health-and-welfare/disease-data-collection/world-animal-health-information-system/). The data were collected from 2016 to 2020. The collected data included the number of outbreaks and the time of year. Additionally, data on the temporal distribution of LSD in different semesters of the year were collected, with the first semester running from January to June (winter and spring) and the second semester running from July to December (summer and autumn). The data were used to create a map depicting the number of outbreaks in different governorates of Egypt during the period of study.

2.*2. Descriptive study of LSDV in two main risk governorates in Egypt (Qalubia and Menofia governorates).*
Field investigation of LSD in two main risk governorates in Egypt according to results of a retrospective study. This study was carried out within the period extended from August 2022 to July 2023 for assessment of the percentage of clinically infected cattle with LSD in Qalubia and Menofia Governorates, Egypt for four seasons (summer, autumn, winter, and spring), depending on data collected by using applied questionnaires from examined animals in the two governorates.

2.3. Ethical approval
This study was approved by the Institutional Animal Care and Use Committee of the Faculty of Veterinary Medicine, Benha University, Qalubia, Egypt (Ethical approval number: BUFVTM 17- 06- 23).

2.4. Statistical analysis
The statistical analysis was carried out using one and two-way ANOVA using SPSS, ver. 27 (IBM Corp. Released 2013). Data were treated as a complete randomization design according to Steel *et al.* (1997). Multiple comparisons were carried out applying for the Duncan test. The significance level was set at < 0.05.

3. RESULTS

The spatial distribution of the LSD prevalence rate in Egypt during the period of study is shown in Figures (1&2). The results demonstrated the significant ($p< 0.05$) variation in the prevalence rates of LSD across the different regions and governorates in Egypt during the period of study. The Delta region had the highest prevalence rate, followed by the Upper Egypt, the Desert, and Canal regions.

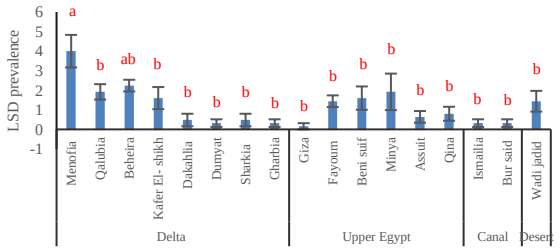

Figure 1 Prevalence rate of LSD in different Egypt governorates during the period of study from 2016 to 2020.

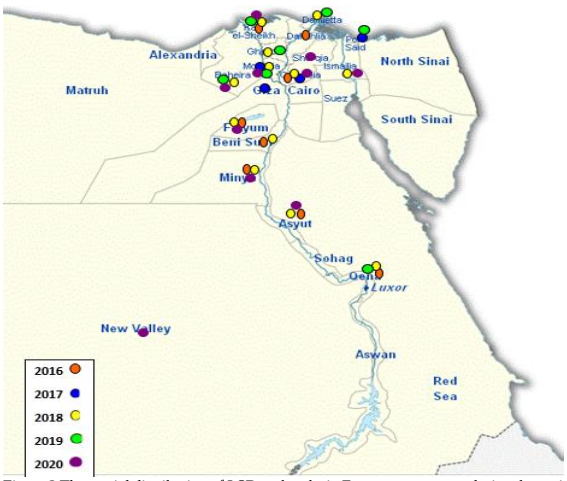

Figure 2 The spatial distribution of LSD outbreaks in Egypt governorates during the period of study from 2016 to 2020.

Menofia recorded the highest prevalence rate (4%) followed by Beheira (2.24%) in the Delta region. In contrast, Giza recorded the lowest LSD prevalence rate (0.16%) in the Upper region.

The temporal distribution of LSD in Egypt through the period of study, was mentioned the results in Figure (3). The results revealed that there was a highly significant difference between the periods from 2016 to 2020. As shown, the highest prevalence rate significantly increased in 2018 (36%). Subsequently, the lowest prevalence rate significantly decreased in 2017 (4%).

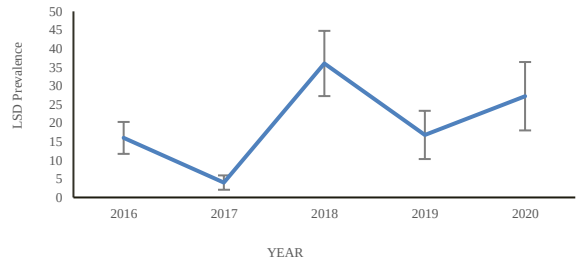

Figure 3 The temporal distribution of LSD outbreaks in Egypt governorates during the period of study from 2016 to 2020.

The different seasons showed a high significant effect on the LSD prevalence rate during the period of study as recorded in Figure (4). The prevalence rate significantly increased in the 2nd semester during the summer and autumn seasons

(16.2%). While it decreased in the 1st semester during the winter and spring seasons (3.84%).

The prevalence rate of LSD in Menofia and Qalubia during the period of study was mentioned in Figure (5). There was a highly significant difference between the two governorates and the LSD prevalence rate was the highest in Menofia compared to Qalubia governorate. The prevalence rate was significantly increased in 2018 in Menofia (8.8%).

Furthermore, different semesters for the period of study from 2016 to 2020 in Menofia and Qalubia Governorates showed highly significant differences in the prevalence of LSD. The 2nd semester of the year recorded the highly significant prevalence rate of LSD during the period of study in Menofia and Qalubia Governorates as shown in Figure (6**)**.

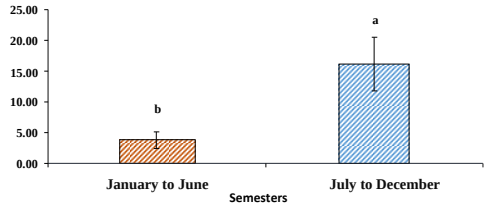

Figure 4 Prevalence rate of LSD in different semesters (January to June and July to December) during the period of study from 2016 to 2020 in all governorates.

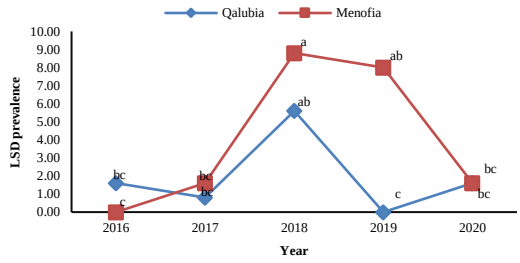

Figure 5 Prevalence rate of LSD in Qalubia and Menofia during the period of study from 2016 to 2020.

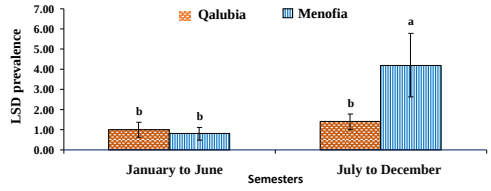

Figure 6 Prevalence rate of LSD in Qalubia and Menofia in different semesters (January to June and July to December) during the period of study from 2016 to 2020.

Our results of the descriptive study revealed that the percentages of clinically infected cattle were higher in Qalubia when compared with Menofia Governorate. In Qalubia, the highest percentages of clinically infected cattle were in age (6-12 months), males, native breeds, non-lactating, pregnant, uniparous, outdoor housing, unvaccinated, and summer (55%, 51%, 56%, 40%, 30%, 38%, 57%, 49%, and 66%) respectively but in Menofia, the percentages of clinically infected cattle were in age (6-12 months), males, native breeds, non-lactating, pregnant, uniparous, outdoor housing, unvaccinated and summer (8%, 0%, 40%, 24%, 13%, 9%, 21%, 33% and 24%) as reported in Table (1).

4. DISCUSSION

Lumpy skin disease (LSD) is an infectious disease affecting cattle and buffalos causing significant economic losses Bazid *et al.* (2022)This disease is known to be endemic in African countries, it continues to spread from its origin and become a serious threat to other Asian and European countries Abutarbush *et al.* (2015) although routine vaccination programs were applied Hodhod *et al.* (2020).

For spatial distribution, our results showed that the prevalence rates of LSD between 2016 into 2020 were highly significantly different (< 0.05) in Egypt governorates in different regions in Egypt. The highest prevalence rates for the period of study from 2016 to 2020 were documented in the Delta region in Menofia (4%), while the lowest prevalence rates were documented in Upper Egypt in Giza (0.16%). This suggests that there are notable differences in the spatial distribution of LSD within Egypt during this period. Our finding is in agreement with Azza Ezzeldin *et al.* (2023) who reported the highest prevalence of LSD appeared in the Delta region where the three main governorates were Dakahlia (15%) and Kafr El-Sheikh (14%) then Sharkia (10%). On the contrary, Mona Dawoud *et al. (*2019) showed that the prevalence rates in (Beni Suif, Qalubia, Dakahlia, Beheira, Fayoum, and Gharbia) were (35.4%, 24.7%, 25.3%, 15.6% 29.6%, and 13.8%) respectively from 2016 to 2017 and Salib and Osman (2011) revealed that the morbidity of LSD among examined Egyptian cattle in Giza Governorate reached (100%). The Delta region spatially appears as one block (no borders between their governorates) and is famous for crops, especially rice Azza Ezzeldin *et al.* (2023) , and the presence of collective areas from water surfaces might accelerate outbreaks development (Gumbe, (2018).

Table 1 Descriptive study of LSD in two main risk governorates in Egypt.

Parameter		Qalubia		Menofia			Total Clinically infected cattle
		Number of cattle	Clinically infected cattle	Number of cattle	Clinically infected cattle	Total cattle	
Age (month)	3-6	30	10	23	0	53	10
	6-12	38	21	76	6	114	27
	12-36	46	18	54	4	100	22
	36-50	71	10	114	18	185	28
Sex	Male	37	19	86	0	123	19
	Female	148	40	181	28	329	68
Breed	Native	25	14	10	4	35	18
	Crossbreed	160	45	257	24	417	69
Lactation	Lactated	73	10	139	18	212	28
	Non lactating	75	30	42	10	117	40
Pregnancy	Pregnant	43	13	46	6	89	19
	Non pregnant	105	27	135	22	240	49
Number of parturition	Heifer	57	21	24	8	81	29
	Uniparous	24	9	47	4	71	13
	Multiparous	67	10	110	16	177	26
Type of housing	Indoor	20	0	25	0	45	0
	Out door	104	59	134	28	238	87
Vaccination	Vaccinated	82	9	183	0	265	9
	Unvaccinated	103	50	84	28	187	78
Season	Summer	35	23	59	14	94	37
	Autumn	51	19	87	8	138	27
	Winter	56	14	65	4	121	18
	Spring	43	3	56	2	99	5

The higher prevalence rates in the Delta region may be attributed to three possibilities, firstly the widespread ~~of~~ cultivated areas with their water bodies providing good environmental conditions for the reproduction and amplification of biting insect populations that act as the most potential risk factor for spreading of LSD in these governorates Molla *et al.* (2017), secondly to some defects in the vaccination process or due to none of the cattle farmers had any experience with vaccination against LSD Arjkumpa *et al.* (2022) and finally may be due to immunocompromised vaccinated animals Molini *et al.* (2018).

For temporal distribution, our results showed that the highest prevalence rate was significantly increased in 2018 (36%) and the lowest prevalence rate was significantly decreased in 2017 (4%).

The LSD outbreaks vigorously appeared in 2018 in Egypt with high morbidity rates and caused economic impacts on milk and meat production Dina Faris *et al.* (2021). In the summer of 2018, the highest prevalence of LSD was (57.8%) in Egypt Azza Ezzeldin *et al.* (2023). These results may be attributed to severe climatic changes before the epidemic LSD outbreak by three months that have a role in the spreading of this disease, as happened in 1989 and 2006 in Egypt Khafagi *et al.* (2022).

In our turn, the highest prevalence rates of LSD more obvious from July to December (summer and autumn) was (16.2%) and decreased from January to June (winter and spring) was (3.84%).

Our results matched those of Mona Dawoud *et al.* (2019) who observed LSD was more common during summer and autumn and Elhaig *et al.* (2021) who reported that the highest number of diseased animals was in June and July, and the lowest was in November, also Dina Faris *et al.* (2021) stated that the prevalence rates were higher in the summer and spring (37.7% and 34.1%, respectively) than the winter season. This may be due to warm and humid weather that increases the insects' propagation and their distribution which is considered the main risk factor of LSDV transmission Chihota *et al.* (2001).

On the contrary, Azza Ezzeldin *et al.* (2023) recorded that the highest prevalence rate in the autumn was (42%) followed by winter at (20%) and Ahmed and Kawther (2008) said that the highest prevalence of LSD was recorded during winter (36.7%) followed by autumn (25.6%). This might be due to unfavorable management and environmental conditions or the importation of new animals from other localities, particularly from Africa Ahmed and Kawther (2008).

The results of a retrospective study revealed that the prevalence rates of LSD from 2016 to 2020 ~~were~~ significantly ~~high~~ increased in Menofia when compared with Qalubia Governorate. On the contrary, the results of a descriptive study from August 2022 to July 2023 revealed that the percentages of clinically infected cattle were higher in Qalubia than in the Menofia governorate. This might be attributed to some defects in the vaccination process in Menofia from 2016 to 2020 Abd Elmohsen *et al.* (2019). After this period, there may be interest in the application of a plan for the prevention and control of LSD and regular vaccination of animals. In addition to restrictions of water canals and cultivated areas that increase insect activity in this region Molla *et al.* (2017).

5. CONCLUSIONS

The evaluation of spatial and temporal distributions conducted between 2016 and 2020 has demonstrated that LSD is a significant endemic disease in Egypt, affecting livestock production and leading to substantial economic losses. The findings indicate that LSD is prevalent throughout various governorates in Egypt, posing a continuous threat to the cattle industry. In light of this, it is imperative to implement more effective preventive and control measures and raise awareness about the disease, particularly in the main risk governorates.

CONFLICT OF INTEREST

The authors announce that they have no Conflict of interest.

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