

USE OF GIS TECHNOLOGIES TO ANALYZE THE SPREAD OF MAREK'S DISEASE VIRUS IN UKRAINE

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Summary. The article presents data on the use of GIS technologies to visualize the spread of Marek's disease virus in Ukraine since 2011. The ArcGis v. 10.4.1 was used as a geographic information system. Three vector maps were designed, with different data on Marek's disease virus outbreaks, and a map showing the density of the poultry population in Ukraine, to better understand the possible risks associated with the spread of the virus and to predict the epizootic situation regarding Marek's disease

Keywords: ArcGis, vector maps, risk assessment

Introduction. Today, the Marek's disease virus (MDV) is a major threat to the poultry industry in Ukraine. Marek's disease is a highly contagious herpesvirus neoplastic disease of poultry and wild birds, which is common in countries around the world.

Vaccination of day-old young birds with live vaccines is the basic strategy for the prevention and control of Marek's disease (Stegniy, 2010; Sostin, Stegnyy B. and Stegnyy M., 2017). Effective vaccination prevents clinical manifestations of MD, such as tumors from latently infected T lymphocytes, but although vaccination reduces infection and its spread, it is not able to completely prevent it (Gerilovych et al., 2010). Annually in countries with developed poultry losses from MD are estimated at 1–2 billion dollars (Morrow and Fehler, 2004). Marek's disease virus belongs to the genus *Mardivirus*, subfamily *Alphaherpesvirinae*, family *Herpesviridae*. There are three serotypes: 1) Gallid herpesvirus 2 (GaHV-2), 2) Gallid herpesvirus 3 (GaHV-3), 3) Meleagrid herpesvirus 1 or herpesvirus of turkeys (HVT). However, only representatives of the first serotype are oncogenic (Murata et al., 2007; Kozdrun et al., 2020). This infectious disease of birds (mainly chickens) is caused by the oncogenic herpesvirus of group B and manifested by paresis, paralysis of the extremities, change in the color of the iris, deformation of the pupil, and tumors in internal organs, skeletal muscles and skin. Under natural conditions, chickens are susceptible to the disease.

Turkeys, guinea fowl, quail and pheasants may be susceptible to infection. Young birds are most susceptible to infection in the first days of life. Marek's disease virus is characterized by pronounced tropism in T lymphocytes, in which it persists for a long time. In the body of a sick bird it is contained in the blood, feces, tumors, pathologically altered organs, as well as in the epithelial cells of feather skin follicles, lymphoreticular cells (legs, comb, wattles). The source of infection is sick birds, as well as clinically healthy birds-virus carriers. The pathogen can be transmitted from the surface of the shell of an infected egg. The incubation period is from 14 days to 6 months. Virus excretion begins 7–20 days

after infection and can continue throughout life. The pathogen spreads to the environment with the epithelium of feather follicles, through the gastrointestinal tract, as well as through the respiratory organs. The main route of infection is aerogenic. Marek's disease can take the form of an epizootic outbreak or be sporadic. If Marek's disease is suspected, measures are taken to clarify the diagnosis. For this purpose, carcasses or sick birds in the amount from 5 to 10 individuals are examined.

During the first week after infection, the virus is found in the thymus, spleen and fabric bursa, from the 23rd day and even earlier — in the epithelium of feather follicles. 5–7 days after inoculation of the pathogen, round cells of various shapes and sizes appear in the blood, then multinucleated giant cells with eosinophilic cytoplasmic granulation and perinuclear inclusions are detected, and by the 10th day foci of star-shaped cells appear. In the stage of nerve damage, circulatory disorders are observed.

Lymphocytes infiltrate the stroma of the nerve that germinates in the connective tissue, as a result, the nerve thickens, changes its normal structure. This leads to disruption of nerve trophism and, as a consequence, disorders of the entire physiological system of metabolic processes, mechanisms of regulation and adaptation, depletion and death (Stegniy B., Stegnyy M. and Sostin, 2014).

Clinical picture. Marek's disease manifests itself at the age of 6 weeks, but more often from 12 to 24 weeks. The incubation period lasts from 3–4 weeks to several months. Previously, the course of MD according to the features of clinical signs and lesions of tissues and organs in sick birds was divided into three forms: neural, ocular and visceral. At present, the course of MD by the form of manifestation is classified into classical and acute. In the classical form, a small percentage of the herd is affected (up to 10%), and in the acute form — 20–30%. Death often begins at 8 weeks of age in laying hens, but its peak usually occurs at 5 months of age (Berezhna, Ivashchenko and Polishchuk, 2015; Morrow and Fehler, 2004).

In the case of artificial infection of day-old chickens that do not have maternal antibodies, death can occur in 3 weeks and even in 10–17 days after depression and stunted growth. The classical form is subacute and chronic. The incubation period of the disease lasts from 2–3 to 6 months. A sick bird dies at the age of 3–5 months.

Acute form of Marek’s disease is characterized by a short incubation period — from several weeks to 2–3 months. The virus with blood leukocytes penetrates the internal organs and spreads in the cells of the lymphoid tissue of the fabric bursa, thymus, spleen, in places of lymphoid infiltration of organs and nerve trunks. Due to the death of lymphocytes, the normal functioning of the immune system is disrupted, which contributes to the generalization of infection and the formation of tumors in many organs. Clinical symptoms of the disease in experimentally infected chickens are manifested by cachexia, paresis and paralysis of the limbs, neck, crop, wings, lesions of the digestive tract, eyes. Their appearance is caused by lesions of internal organs, tumors that lead to a general violation of the bird body. In some cases, outbreaks are dominated by skin lesions. This form occurs suddenly, is rapid, and is characterized by high morbidity and mortality of up to 80% of chickens aged from 1 to 5 months.

Summarizing the above, it should be noted that among infectious diseases of birds, Marek’s disease continues to be widespread throughout the world. In this regard, due attention should be paid to monitoring, specific prevention and control measures.

Cartographic methods are widely used for monitoring studies of animal and human diseases, which allow to study the patterns of spatial location of objects and certain aspects of the development of disease epizootics in a particular area by compiling and using nosological maps.

A new stage of technological development is characterized by the emergence of geographic information systems (GIS). Geoinformation system — computer technology that allows you to combine a model image of the territory with tabular information (statistics, lists, economic indicators, epidemiological data, etc.) (Kaliuzhnyi and Ushkalov, 2013; Mengistu and Haile, 2017).

The work aimed to visualize the spread of Marek’s disease virus in Ukraine using GIS technologies.

Materials and methods. The research was conducted based on analysis of the epizootic situation in Ukraine and worldwide, own monitoring research and patent-license search in PubMed databases, and with the use of geographic information system (GIS technologies). Preliminary MD was diagnosed based on epizootic data, symptoms of the disease (lesions of the peripheral and central nervous system in the classical form of MD, almost any nerve can be affected, and the symptoms can be varied: lameness, paresis, ataxia, paralysis of one or two limbs, wings, neck, and tail. The clinical signs of the acute form of the disease are often nonspecific: lethargy,

anemia, sometimes shortness of breath and cough, indigestion, exhaustion, refusal to feed, dehydration, etc.), and characteristic pathological and anatomical changes. At the autopsy of the dead bird, in the case of the classical form, diffuse-focal thickening of the nerve trunks of the lumbar and humeral plexuses is found, which acquire a dull gray color.

Tumor-like growths are observed in the lungs, kidneys, heart, and gonads. In the carcasses of birds that died of acute Marek’s disease, there are single (in the initial stage) and later — numerous tumors in the internal organs, skin, muscles, rarely — changes in the nerves. Tumors are usually found in the ovaries, heart, glandular stomach, lungs, skeletal muscles, less often in the cloacal sac, kidneys, liver and spleen. At the same time, the liver and spleen increase in sizes several times, and the wall of a glandular stomach thickens 2–5 times.

For final diagnosis, from 5 to 10 clinically sick chickens are sent to the laboratory, where blood is taken, and pathological material during the autopsy: pieces of affected organs, nerves, skin. On the other hand, from the outer surface of the thigh of each bird 10–15 feathers with the presence of tissue (epithelium of feather follicles) are taken. Pathological material is used for virological (not later than 2–3 h after collection) and molecular-genetic (PCR) (Murata et al., 2007) or pathomorphological studies.

This work used data for the period 2011–2021. 57 samples of biological material from dead birds were examined for the presence of MDV, studies were performed by molecular-genetic and virological methods, the results of these studies revealed a total of 39 positive samples. Experimental studies on animals have been conducted following the basic principles of bioethics. Euthanasia of animals was performed by inhalation of chloroform anesthesia.

We used ArcGis v. 10.4.1 as a GIS. Then, with the help of Microsoft Excel, a table in CSV format was created (Fig. 1), in which data on cases of MDV detection were entered.

	A	B	C	D	E	F	G	H	I	J
1	rigeon	lat	lon	sample	pos(+)					
2	Київська с	50.181142	31.176197	14	10					
3	Харківська	49.720425	36.053826	15	2					
4	Одеська с	46.488870	30.735911	4	4					
5	Дніпропе	48.048586	33.278268	2	1					
6	Черкаська	50.056896	32.067046	1	1					
7	Вінницька	49.658925	28.458526	3	3					
8	Харківська	50.393993	35.825338	3	3					
9	Чернівець	48.18915	26.011871	3	3					
10	Харківська	50.166306	36.418067	6	6					
11	Київська с	49.318836	29.773266	4	4					
12	Сумська с	50.891106	34.816974	2	2					

Figure 1. Tabular data in CSV format

Fig. 1 shows the location of MDV outbreaks, the number of positive and negative samples.

After that the data was transferred to ArcGis program, which was later converted into an attribute table. Then all the data with the help of the 'data display' function (Fig. 2), the coordinates of the MDV pathogens outbreaks were plotted on the map.

Results. According to the monitoring results, two maps were created, one with the marked outbreaks of MDV, which have been detected since 2011, and with the marked poultry farms of Ukraine, the data of which were taken from open sources (Fig. 3).

A map was also created with the same data, but with additional data on the number of positive and negative samples, which were plotted on the map in the form of pie charts (Fig. 4).

Subsequently, we created a map of Ukraine with marked data on poultry population. The statistics on the number of poultry of all species in farms of all categories were taken from official site of the State Statistics Service of Ukraine (http://www.ukrstat.gov.ua/druk/publicat/kat_u/2020/zb/05/zb_tvaryny_2019.pdf).

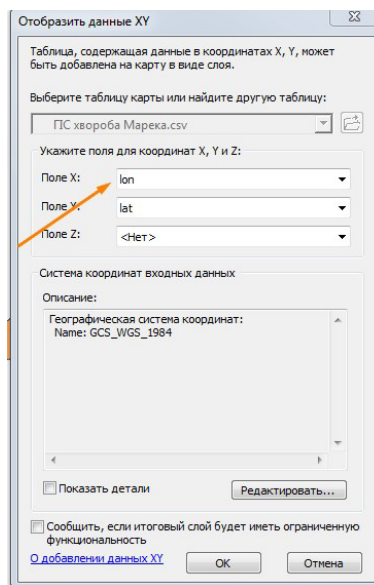


Figure 2. Data display function

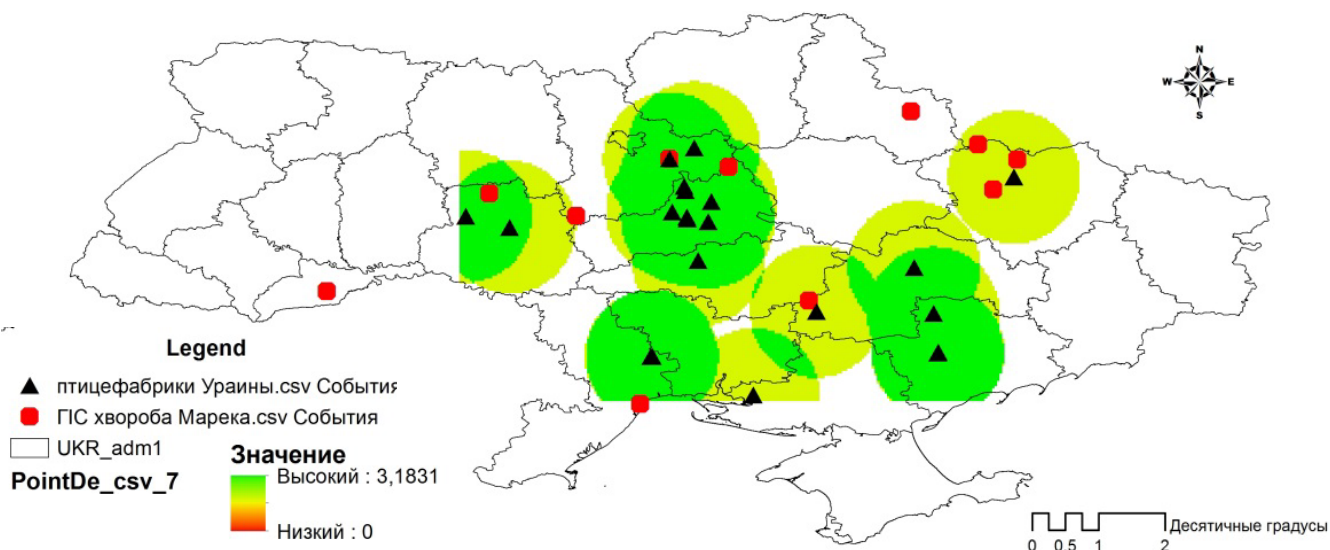


Figure 3. Map of Ukraine with data on MDV outbreaks and poultry farms

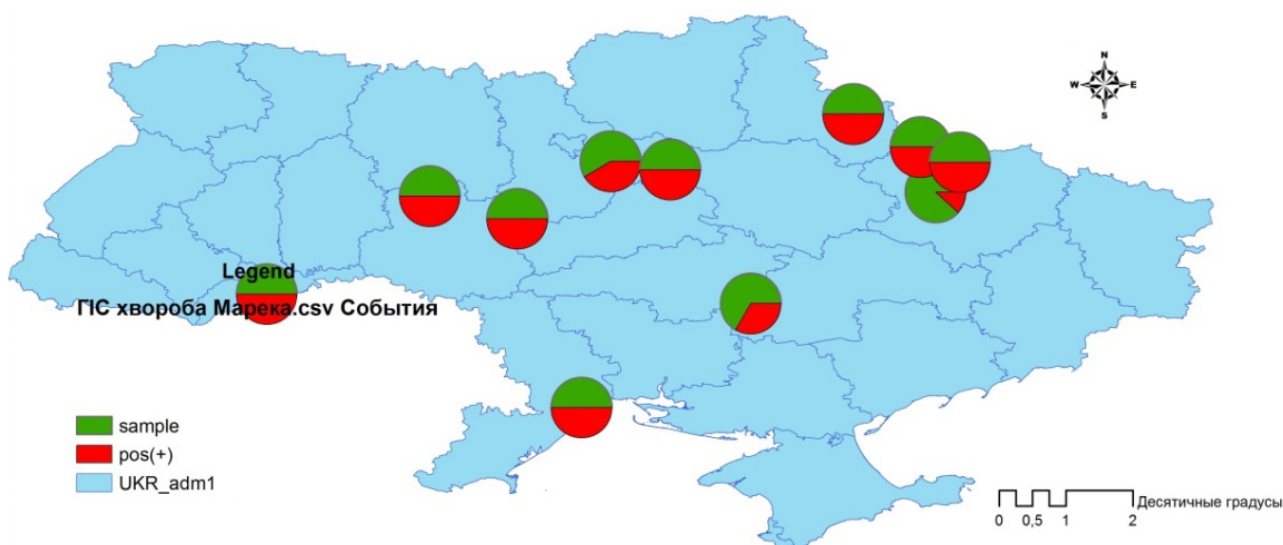


Figure 4. Map of Ukraine with data on MDV outbreaks in the form of pie charts

Two additional columns were created in the attribute table, which included data on the number of poultry in each region, and data on the area of these regions (Fig. 5).

Then a map was created, which visually displayed the poultry population in the form of points (Fig. 6).

1	NAME 1	TYPE 1	ENGTYP 1	NL_NAME 1	VARNAME 1	poultry	area
4	Crimea	Autonomous Republic	Autonomous Republic	Crimée Criméia Krim Krymskaya Respublika Respublika Krym		0	0
11	Kiev City	Independent City	Independent City	Kyiv		0	0
20	Sevastopol	Autonomous Republic	Autonomous Republic	Sebastopol		0	0
1	Cherkassy	Oblast'	Region	Cherkas'ka Oblast' Cherkasskaya Oblast' Cherkassy		25261	20916
2	Chernihiv	Oblast'	Region	Chernigov Tschernigow		3548	31903
3	Chernivtsi	Oblast'	Region	Chernivets'ka Oblast' Chernovitskaya Oblast' Chernowitz Tschernowzy Tchernovtsy		3726	8096
5	Dnipropetrovsk	Oblast'	Region	Dnipropetrovsk Dniepropetrovsk Dnjepropetrovsk		17763	31923
6	Donets'k	Oblast'	Region	Donetsk Donetskaya Oblast' Donezki Stalino		6104	26517
7	Ivano-Frankivs'k	Oblast'	Region	Ivano-Frankovsk Ivano-Frankovskaya Oblast' Stanislav		4908	13927
8	Kharkiv	Oblast'	Region	Charkov Jarkov Karkov Khar'kov		8151	31418
9	Kherson	Oblast'	Region	Cherson Kherson's'ka Oblast'		5703	28461
10	Khmelnytsky	Oblast'	Region	Khmelnytsky Khmelnytskyi Chmelniczki Hmelnicki Kamenets'-Podolskaya Oblast' Khmelnyts'ka Oblast'		8157	20629
12	Kiev	Oblast'	Region	Kiev Oblast' Kew Kjew Kiiv Kjev Kyevi Kyiv Kyjiv Kyryvi Kyryvs'ka Oblast'		31387	28121
13	Kirovohrad	Oblast'	Region	Kirovograd Kirovogradskaya Oblast'		5481	24588
14	L'viv	Oblast'	Region	Lemberg Lvov L'viv L'wow L'vivs'ka Oblast'		9914	21831
15	Luhans'k	Oblast'	Region	Luhansk Lugansk Luhans'ka Oblast' Voroshilovgrad		931	26684
16	Mykolajiv	Oblast'	Region	Mykolajiv Nikolajew Nikolajev		2453	24585
17	Odessa	Oblast'	Region	Odesa Odes'ka Oblast' Odesskaya Oblast'		2624	33314
18	Poltava	Oblast'	Region			5388	28750
19	Rivne	Oblast'	Region	Rovno Rivnens'ka Oblast' Rovenskaya Oblast'		7286	20051
21	Sumy	Oblast'	Region			5310	23832
22	Ternopil'	Oblast'	Region	Ternopol Ternopol'		5197	13824
23	Transcarpathia	Oblast'	Region	Transcarpathian Zakarpattia Ruthenia Zakarpats'ka Oblast' Zakarpatskaya Oblast'		3572	12753
24	Vinnycya	Oblast'	Region	Vinnycia Vinnitskaya Oblast' Vinnyc's'ka Oblast' Winniza		37550	26492
25	Volyn	Oblast'	Region	Volhynia Volyn's'ka Oblast' Volynskaya Oblast' Volynien		7759	20144
26	Zaporizhzhya	Oblast'	Region	Saporoshje Zaporizhia Zaporiz'ka Oblast' Zaporozje Zaporozhskaya Oblast' Zaporozh'ye Zaporoz'je		4952	27183
27	Zhytomyr	Oblast'	Region	Zhitomir Jtomir Shtomir Zhitomirskaya Oblast'		7416	29827

Figure 5. Table of attributes with the marked data on the number of poultry in the country



Figure 6. Map of Ukraine showing poultry population

Conclusions. Thus, according to the results of our research, three maps were created, two of which showed MDV outbreaks, in two different ways, one map showed disease outbreaks with additional application of poultry farms in Ukraine, the other the same data, but in the form of pie charts showing positive and negative samples, for more detailed visualization.

The map of Ukraine showing the poultry population showed the distribution of poultry in Ukraine in the form of points. This map was created for a more detailed understanding of the areas of animal accumulation, linking this factor with the possible further spread of Marek's disease outbreaks in areas of poultry concentration.

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