DOI https://doi.org/10.30525/978-9934-26-570-9-39

ENVIRONMENTAL CONSEQUENCES OF THE KAKHOVSKA HPP EXPLOSION: RISKS OF MALARIA SPREAD UNDER MARTIAL LAW CONDITIONS

Voronova N. V., Horban V. V.

INTRODUCTION

For centuries, humanity has been combating malaria, yet it continues to claim nearly 0.5 million lives annually worldwide. WHO experts assert that there are no biological or environmental barriers to its elimination. Consequently, to alleviate the global disease burden, the MalERA Refresh advisory group has proposed an updated program for multifaceted, integrated research, aiming to unite scientific efforts in human immunology, parasitology, and entomology [1].

Malaria cases are on the rise in many countries and regions previously deemed free of the disease. A significant factor contributing to this resurgence is human migration, driven by various causes such as environmental degradation, economic necessity, military conflict, and natural disasters. These factors disproportionately affect the poor, many of whom reside in or near malaria-endemic areas. Understanding the impact of these population movements can enhance malaria prevention and control programs.

Ukraine's current legal framework for malaria prevention is established through national legislation, including:

– Law of Ukraine "On the Protection of the Population from Infectious Diseases" No. 1645-III (2000) https://zakon.rada.gov.ua/laws/show/1645-14#Text;

– Law of Ukraine "On Ensuring Sanitary and Epidemic Welfare of the Population" No. 4004-XII (1994) https://zakon.rada.gov.ua/laws/show/4004-12#Text;

– "Rules for Sanitary Protection of the Territory," approved by Cabinet of Ministers Resolution No. 893 (August 22, 2011) https://zakon.rada.gov.ua/laws/show/893-2011-%D0%BF#Text;

– Ministry of Health Order No. 113 (March 12, 2007): "On the Approval of Methodological Guidelines for Planning Measures to Prevent the Introduction and Spread of Dangerous Infectious Diseases in Ukraine" https://zakon.rada.gov.ua/rada/show/v0113282-07#Text;

[1] Безсимптомна малярія, еритропоез та плазмодій / В. І. Павліченко, О. Б. Приходько, Т. І. Ємець, Г. Ю. Малєєва // Екологічні науки. 2022. N 1. С. 99-103. https://doi.org/10.32846/2306-9716/2022.eco.1-40.18.

– Resolution of the Chief State Sanitary Doctor of Ukraine No. 19 (November 7, 2011): "On Measures to Prevent Malaria in Ukraine" https://zakon.rada.gov.ua/rada/show/v0019488-11#Text.

1. The problem's prerequisites emergence and the problem's formulation

Health priorities vary between countries and evolve significantly over time. A key concern for governments planning over decadal timescales is the potential impact of environmental and climate change on health and well-being. [2]. These impacts are complex and multifaceted, including the potential for climate change to alter the temporal and spatial burden of communicable diseases such as malaria.

In recent years, Ukraine has experienced an increase in malaria cases, with approximately 50 cases registered annually. The relevance of malaria to Ukrainians stems from several factors: a growing number of individuals independently visiting endemic regions (due to war, tourism, or cultural exchanges), inadequate preventive measures before and during stays in endemic zones, the absence of modern antimalarial drugs registered in the country, insufficient medical vigilance, delayed diagnoses, and other contributing factors. [3].

Malaria remains one of the most prevalent diseases globally. In Ukraine, the infection was eradicated in 1956, and since then, it has been recorded only as isolated imported cases. However, local transmission also occurs. The primary challenges associated with malaria in Ukraine are early diagnosis and effective treatment.

Malaria mosquitoes have historically posed a problem in Ukraine, disrupting outdoor activities during warm seasons, affecting livestock, and causing general discomfort. Concurrently, rapid climate changes have been observed in recent decades. Rising temperatures, altered moisture distribution, and the creation of artificial water bodies (such as irrigation systems and reservoirs) have created highly favorable conditions for certain mosquito species [4].

---

[2] Верба Н. В. Малярія. // Сучасні теоретичні та практичні аспекти клінічної медицини: науково-практична конференція з міжнародною участю, присвячена 150 річчю з дня народження В. В. Вороніна, Харків, 9-10 квітня 2020, С.75.

[3] Нечипоренко О. В. До проблеми малярії в Україні / О. В. Нечипоренко, Н. В. Анциферова . Актуальні питання експериментальної та клінічної медицини: матеріали міжнародної науково-практичної конференції студентів, молодих вчених, лікарів та викладачі, Суми, 25–26 квітня 2007 р. : тези доповідей. Суми, 2007. С. 51–52.

[4] Воронова Н.В. Кровосисні двокрилі (Diptera) степового Придніпров'я: монографія / Воронова Н.В., Горбань В.В., Павліченко В.В. Запоріжжя: ЗНУ, 2008. 208 с.

The purpose of the work: to investigate the ecological aspects of malaria in Ukraine following the destruction of the Kakhovska Reservoir dam due to Russian aggression.

To realize the goal, the following tasks were set:

- Determine the species composition of malaria mosquitoes in Ukraine;
- Identify the types of malaria pathogens in the Zaporizhzhia region;
- Calculate the key dates of the malaria season in the study area.

The object of research is malaria mosquitoes (*Culicidae*) in Ukraine, which are vectors of malaria pathogens.

Subject of research: ecological conditions influencing the transmission of malaria pathogens in Ukraine.

Scientific novelty: This study is novel in its examination of recent climatic changes and the heightened influence of anthropogenic factors due to military actions. The destruction of the Kakhovska Reservoir dam in June 2023 has altered the habitat conditions for malaria mosquitoes, including those capable of transmitting malaria pathogens.

Practical significance: The findings will help identify environmental factors linked to the spread of malaria pathogens by blood-sucking mosquitoes, enabling the development of measures to control their populations and prevent the dissemination of malaria among Ukraine's population.

2. Analysis of the Malaria situation in Ukraine

Air temperature data used to assess the possibility of sporogony in the Zaporizhzhia region during winter and summer were obtained from average winter and summer isotherm maps in the Zaporizhzhia meteorological archive (Meteoblue) for 2022–2023. The prognostic assessment of changes in Ukraine's average annual surface temperature is based on O. Shevchenko's work [5], which provides projections of average monthly temperature changes by region relative to the climatic norm.

To evaluate the potential for malarial plasmodia to complete full sexual development in mosquitoes, we considered temperature thresholds that vary by pathogen type. According to Grassi (1900), the minimum development temperatures are 16.5°C for *P. malariae,* 17.5°C for *P. vivax,* and 18°C for *P. falciparum*[6]. The duration of the sporogony process for *P. vivax* at different air temperatures was determined using Ohanov-Raevsky's method.

[5] Шевченко, О. Оцінка вразливості до зміни клімату. Кліматичний форум східного партнерства та Робоча група громадських організацій зі зміни клімату. 2014. 74 С.

[6] О.Г. Забарна, О.О. Халаїм. Оцінка впливу температурних показників на формування маляріогенності території України. Національний університет «Києво-Могилянська академія» Інфекційні хвороби.https://www.researchgate.net/publication/313593234_OCINKA_VPLIVU_TEMPERATURNIH_POKAZNIKIV_NA_FORMUVANNA_MALARIOGENNOSTI_TERITORII_UKRAINI. 2016. Випуск 4. С.86-92

The number of days with temperatures above 16°C was calculated using data from A. Field et al.[7], who identified Ukraine's natural and climatic regions and the duration of periods with air temperatures above 15°C for 1991–2005 and projected to 2030. The study results are presented for five main regions: the Northern region (including Polissia), the Western region (including Prykarpattia and Transcarpathia), the Central region (Forest Steppe), the Eastern region (including the Northern Steppe), and the Southern region (including the Southern Steppe and temporarily occupied Crimea).

The malaria transmission period was determined retrospectively using average daily air temperatures from https://surl.li/dbncbo, starting from the day when the average daily temperature reached +16°C.

We employed M.D. Moshkovsky's method, which requires a specific sum of effective temperatures to complete sporogony in malaria mosquitoes (105°C for *P. vivax*). From the average daily temperature, 14.5°C (the lower threshold) was subtracted, and the daily differences were summed until 105°C was reached. The following day was considered the start of the transmission season. Temperatures above 35°C hinder plasmodia development, and at 36°C or higher, they die.

To determine the start of the malaria transmission season, we calculated the sporogony cycle duration for *P. vivax* (105°C with a lower threshold of +16°C). Days with temperatures below +16°C were excluded from the sum, but subsequent favorable days were included, as *P. vivax* remains viable for 14 days at +15°C and dies within two days at 10°C or below. If temperatures dropped for more than 10 days, calculations were restarted. The duration of *P. vivax* sporogony in *Anopheles* mosquitoes under various temperature conditions is detailed in Appendix 1.

The end of the malaria season was calculated in August–September, based on the last day with an average daily temperature of at least 16°C (excluding short warming periods). From this date, the last sporogony cycle was calculated in reverse until the sum of plasmodia development percentages reached 100%. This date marked the end of the malaria season.

We also calculated the physiological age of female malaria mosquitoes capable of transmitting pathogens by determining the number of gonotrophic cycles completed during one sporogony cycle. A gonotrophic cycle requires 36.5°C of heat accumulation above 9.9°C. We subtracted 9.9°C from the average daily temperature (≥16°C) and summed the differences until 36.5°C was reached. The next day was skipped (for blood digestion, egg laying, etc.), and the process repeated until sporogony ended.

These calculations assess the epidemiological threat of local malaria transmission. Only mosquitoes completing sporogony within seven

[7]Польовий, А., Божко, Л., Дронова. Аналіз тенденції змін термічних показників агрокліматичних ресурсів в Україні за період до 2030–2040– 2011.№9.С.90-99.

gonotrophic cycles are epidemiologically significant. If few or no such females are present, transmission is unlikely, even with a large mosquito population.

Disinsecticide treatments are conducted based on epidemiological and phenological indicators when imported or local malaria cases are present and vector populations are high in protected areas.

– The first treatment targets mass mosquito emergence after wintering (in early warm springs with registered malaria cases) to prevent summer generation development.

– The second treatment targets water bodies when 2–3 instar larvae are observed, as older larvae are more insecticide-resistant.

– The third treatment occurs at the start of the malaria season, as summer-generation mosquitoes are most epidemiologically significant due to their large population, close human contact, and the presence of potentially dangerous females.

– At the end of the transmission season, continuous monitoring of female physiological states is necessary to avoid treating diapausing females.

This study on the ecology of Ukraine's malaria mosquitoes and their transmitted pathogens is based on literature, official data from the Zaporizhzhia State Medical Center, and our research on development biotopes in the Zaporizhzhia region's floodplain and reservoirs remaining after the Kakhovska HPP dam destruction on June 6, 2023.

Malaria mosquitoes are ubiquitous in Ukraine (Table 1), particularly three species: *An. plumbeus* Steph., *An. claviger* (Mg.), and *An. maculipennis* Mg., recorded in all geographical zones.

In the steppe zone, five malaria mosquito species are recorded, with *An. maculipennis* Mg. being the dominant and primary malaria vector. For this species and *P. vivax*, we calculated key indicators for malaria transmission potential in Ukraine.

Using 2022 average daily temperature data from https://surl.li/dbncbo, we analyzed the malarial potential in the Zaporizhzhia region (Figures 1–6).

Table 1

Systematic List of Malaria Mosquitoes in Ukraine by Climatic Zone[8]

Types of mosquitoes	**Forested**	**Forest steppe**	**Steppe**	**Carpa-thians**	**Trans-carpathia**	**Southern coast of Crimea**
Family Culicidae						
Subfamily Anophelines						
1. An. algeriensis Theob.			□			
2. An. plumbeus Steph.	□	□	□	□	□	□
3. An. key player (Mg.)	□	□	□	□	□	□
4. An. pen Mg.	□	□	□	□	□	□
An. m. maculipennis Mg.						
To. m.messeae Fall.			□			
The. m. arthroparvus V.Th.			□			
5. An. hyrcanus (Pall.)	□	□	□	□		

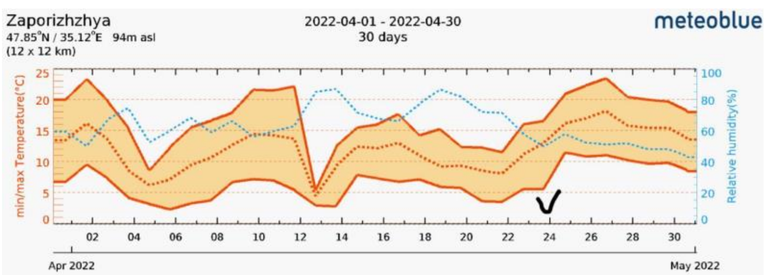

Fig. 1. Average daily temperature for April 2022

[8] Воронова Н. В. та інші. Епідеміологічне значення кровосисних членистоногих рекреаційних зон Північно-Західного Приазов'я. Вісник Запорізького національного університету. Запоріжжя: ЗНУ. 2009. С. 126.

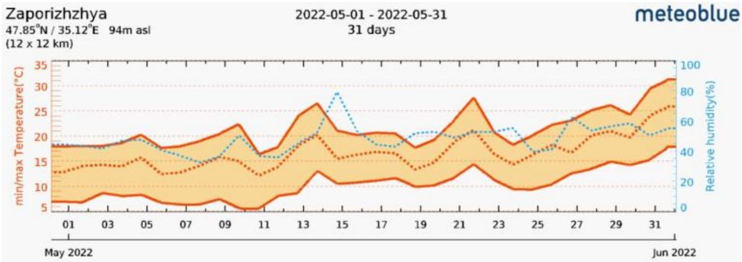

Fig. 2. Average daily temperature for May 2022

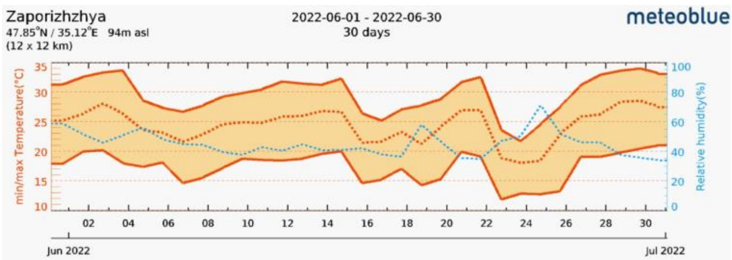

Fig. 3. Average daily temperature for June 2022

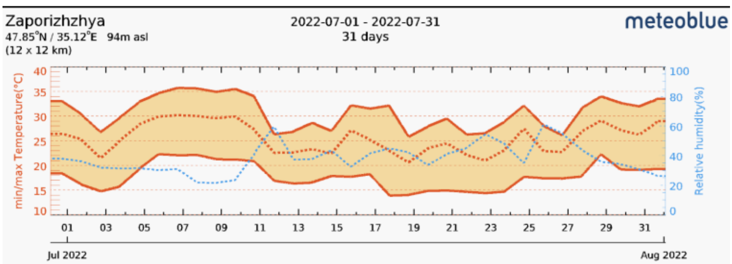

Fig. 4. Average daily temperature for July 2022.

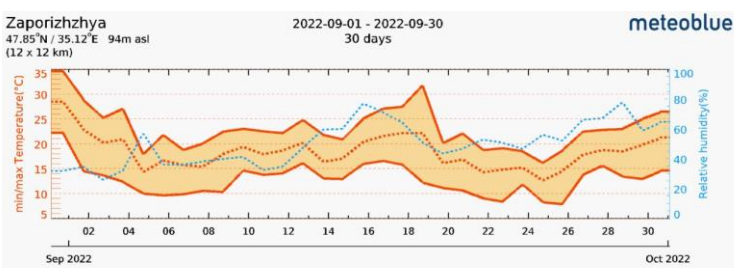

Fig. 5. Average daily temperature for September 2022

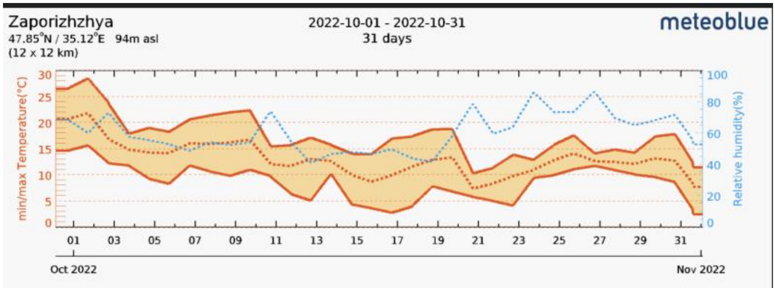

Fig. 6. Average daily temperature for October 2022

Based on these temperatures, the optimal development period for malaria mosquitoes began on April 24, 2022, when temperatures exceeded 16°C. Table 2 indicates that overwintered female malaria mosquitoes in the Zaporizhzhia region posed a threat from May 22, 2022, as they could transmit *P. vivax*.

Table 2

Calculation of Key Malaria Episeason Dates for *P. vivax* in Zaporizhzhia Region, 2022

Date	**Avg. Daily Temp (°C)**	**Effective Temp. Diff.**	**% Sporogony Development (1 day before completion)**	**Calculation for 1 Egg Laying (Avg. Temp – 9.9°C)**	**Notes**	**Avg. Daily Temp (°C)**
24.04	16	1,5	3,17	6,1	Start of malaria season	
25.04	19	4,5	5,4	9,1		
26.04	21	6,5	6,66	11,1		
27.04	16	1,5	3,17	6,1		
28.04	16,2	1,7	3,22	6,3	38,7	1st gonotrophic cycle ended
Continuation of table 2						
29.04	15,8	1,3	3,03	5,9	1 egg-laying	
30.04	16	1,5	3,17	6,1		
01.05	14,8	0,3	2,04	4,9		
02.05	15	0,5	2,22	5,1		
03.05	15,8	1,3	3,03	5,9		
04.05	16	1,5	3,17	6,1		
05.05	15,9	1,4	3,03	6		

06.05	15,8	1,3	3,03	5,9	40	2nd gonotrophic cycle ended
07.05	16	1,5	3,17	6,1	2 egg-laying	
08.05	15,8	1,3	3,03	5,9		
09.05	16	1,5	3,17	6,1		
10.05	15,9	1,4	3,03	6		
11.05	16	1,5	3,17	6,1		
12.05	16,2	1,7	3,22	6,3		
13.05	16	1,5	3,17	6,1		
14.05	16,4	1,9	3,39	6,5	43	3rd gonotrophic cycle ended
15.05	16	1,5	3,17	6,1	3 egg-laying	
16.05	16,3	1,8	3,22	6,4		
17.05	17	2,5	3,85	7,1		
18.05	16	1,5	3,17	6,1		
19.05	15,8	1,3	3,03	5,9		
20.05	19	4,5	5	9,1		
21.05	21	6,5	6,66	11,1	45,7	4th gonotrophic cycle ended
22.05	22	7,5	8		4 egg-laying	sporogony ends (105.8), start of transmission season for *P. vivax*

Another important indicator for understanding the timing of possible infection with the causative agent of malaria is the end of the malaria season, the calculation of which is presented in Table 3. According to our calculations, female malaria mosquitoes this year no longer posed a threat on September 12.

Table 3

Calculation of the End of the Malaria Season Based on September–October 2022 Temperatures

Date	**Avg. Daily Temp (°C)**	**Effective Temp. Diff.**	**% Sporogony Development (1 day before completion)**
12.09	20	5,5	5,26
13.09	18	3,5	3,45
14.09	17	2,5	2,6
15.09	18	3,5	5,26

16.09	19	4,5	5,26
17.09	20	5,5	5,26
18.09	21	6,5	5,8
19.09	22	7,5	6,66
20.09	17	2,5	2,6
21.09	16,4	1,9	2,13
22.09	16,4	1,9	2,13
23.09	16,2	1,7	1,96
24.09	16	1,5	1,82
25.09	15,8	1,3	0
26.09	16	1,5	1,82
27.09	18	3,5	3,45
28.09	19	4,5	4,08
29.09	20	5,5	5,26
30.09	21	6,5	5,8
01.10	22	7,5	6,66
02.10	21	6,5	5,8
03.10	20	5,5	5,26
04.10	19	4,5	4,08
05.10	17	2,5	2,6
Continuation of table 3			
06.10	15,8	1,3	0
07.10	16	1,5	1,82
08.10	16	1,5	1,82
09.10	17	2,5	2,6
10.10	16	1,5	1,82
Total			103,06

Similar calculations for 2023 (Figures 7–12, Table 4) assess how the Kakhovska HPP dam destruction on June 6, 2023, affected the region's climate and malaria situation.

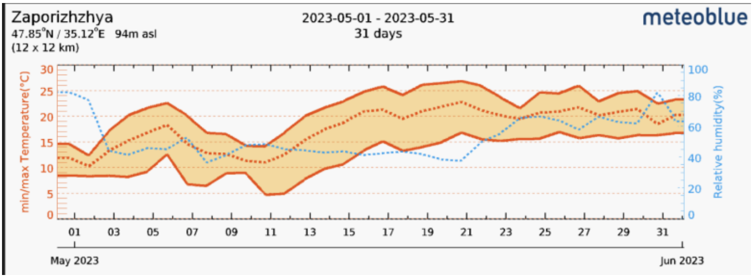

Fig. 7. Average daily temperature for May 2023

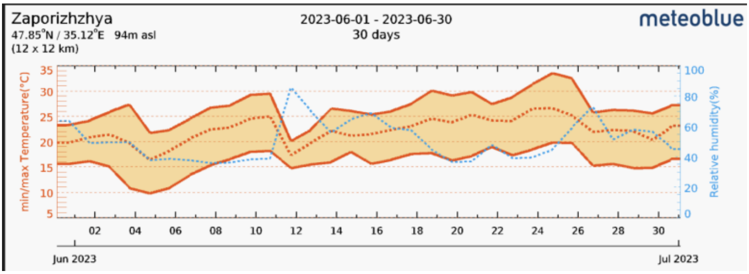

Fig. 8. Average daily temperature for June 2023

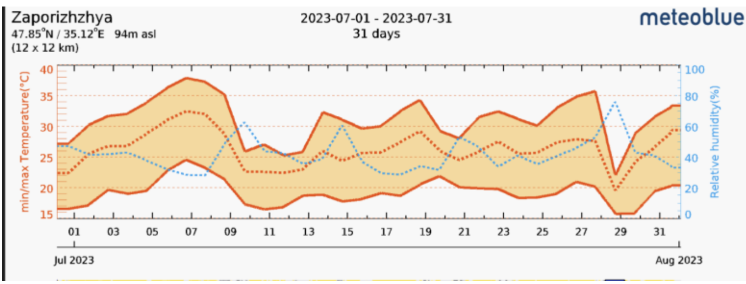

Fig. 9. Average daily temperature for July 2023

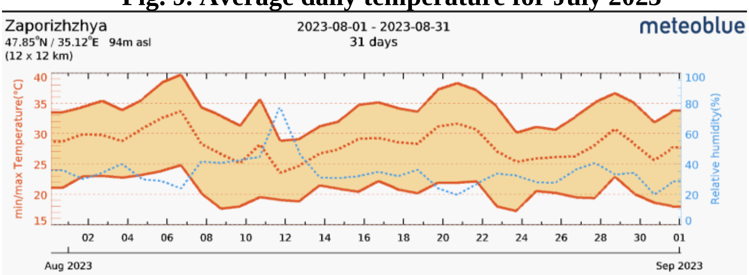

Fig. 10. Average daily temperature for August 2023

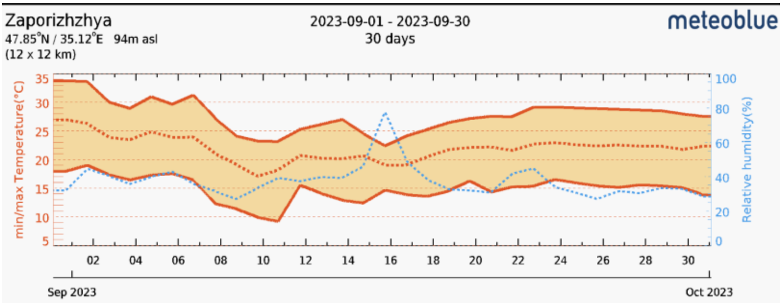

Fig. 11. Average daily temperature for September 2023

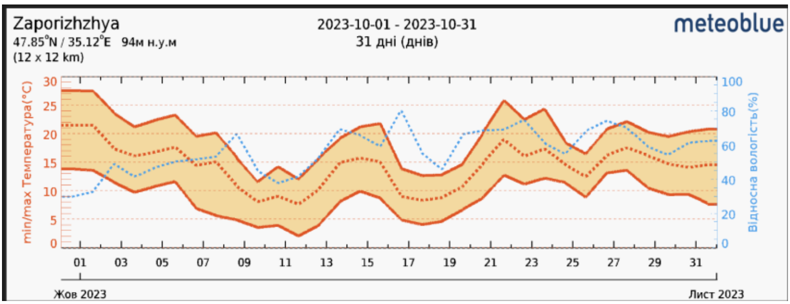

Fig. 12. Average daily temperature for October 2023

Table 4

Calculation of Key Malaria Episeason Dates for *P. vivax* in Zaporizhzhia Region, 2023

Date	Avg. Daily Temp (°C)	Effective Temp. Diff.	% Sporogony Development (1 day before completion)	Calculation for 1 Egg Laying (Avg. Temp – 9.9°C)	Notes	Avg. Daily Temp (°C)
13.05	16	1,5	1,82	6,1	Start of malaria season	
14.05	19	4,5	4,08	9,1		
15.05	21	6,5	5,8	11,1		
16.05	22	7,5	6,66	12,1	38,4	1st gonotrophic cycle ended
17.05	21	6,5	5,8	11,1	1 egg-laying	
18.05	20	5,5	5,26	10,1		
19.05	22	7,5	6,66	12,1		
20.05	21	6,5	5,8	11,1		

21.05	23	8,5	8	13,1	46,4	2nd gonotrophic cycle ended
22.05	22	7,5	6,66	12,1	2 egg-laying	
Continuation of table 4						
23.05	20	5,5	5,26	10,1		
24.05	21	6,5	6,66	11,1		
25.05	22	7,5	6,66	12,1		
26.05	22	7,5	6,66	12,1	45,4	3rd gonotrophic cycle ended
27.05	20	5,5	5,26	10,1	3 egg-laying	
28.05	21	6,5	6,66	11,1		
29.05	20	5,5	5,26	10,1		
30.05	19	4,5	4,08	9,1		
31.05	20	5,5	5,26	10,1	40,4	4th gonotrophic cycle ended
01.06	20	5,5	108,3	10,1	4 egg-laying, start of *P. vivax* transmission	

Thus, key malaria episeason dates (Tables 5–6) are essential for analyzing population incidence and planning antimalarial measures.

Table 5

Calculation of the End of the Malaria Season Based on September–October 2023 Temperatures

Date	**Avg. Daily Temp (°C)**	**Effective Temp. Diff.**	**% Sporogony Development (1 day before completion)**
12.09	20	19	5,26
13.09	18	29	3,45
14.09	20	19	2,6
15.09	18	29	5,26
16.09	20	19	5,26
17.09	20	19	5,26
18.09	21	17	5,8
Continuation of table 5			
19.09	22	15	6,66

20.09	21	17	2,6
21.09	20	19	2,13
22.09	20	19	2,13
23.09	19	24,5	1,96
24.09	18	29	1,82
25.09	20	19	0
26.09	19	25,5	1,82
27.09	18	29	3,45
28.09	23	12,5	4,08
29.09	20	19	5,26
30.09	24	11	5,8
01.10	23	12,5	6,66
02.10	21	17	5,8
03.10	16	55	5,26
04.10	19	24,5	4,08
05.10	17	38,5	2,6
06.10	15,8	55	2,6
07.10	16	55	1,82
08.10	16	55	1,82

Data analysis indicates that sporogony in overwintering female malaria mosquitoes ends in late May to early June, during which they complete four gonotrophic cycles, consistent with modern Ukrainian research [9] .

Ukraine's climatic conditions support the sexual development of *P. vivax* and *P. malariae* in mosquitoes across all regions during summer. For *P. falciparum*, an average seasonal temperature of at least 18°C is required, which is not currently met nor projected for the Western region. Winter temperatures in Ukraine are suboptimal for sporozoite development, acting as a limiting factor for malaria spread [10,11].

---

[9] Безсимптомна малярія, еритропоез та плазмодій / В. І. Павліченко, О. Б. Приходько, Т. І. Ємець, Г. Ю. Малєєва // Екологічні науки. 2022. N 1. С. 101. https://doi.org/10.32846/2306-9716/2022.eco.1-40.18.

[10] Voronova N. V., Tiutiunnyk M. O., Kulik A. . The role of blood-sucking mosquitoes in the transmission of pathogens of various etiologies. The 8th International scientific and practical conference "Scientific research in the modern world" Canada: Perfect Publishing, 2023. С. 28. URL:https://sci-conf.com.ua/wp-content/uploads/2023/06/SCIENTIFIC-RESEARCH-IN-THE-MODERN-WORLD-1-3.06.23.pdf.

[11] Виноград Н. О., Шуль У. А. Прогнозування модифікації природних комариних осередків особливо небезпечних інфекцій в Україні під впливом кліматичних змін. Інфекційні хвороби. Львів: Львівський національний медичний університет 2021. №. 3. С. 10.

Table 6

Key Malaria Episeason Dates in Zaporizhzhia Region, 2022–2023

Year	Flight of Malaria Mosquitoes	End of Sporogony (Overwintering Females)	1st Generation	2nd Generation	3rd Generation	4th Generation	End of Malaria Season
2022	24.04	22.05	28.04	06.05	14.05	21.05	11.10
2023	13.05	01.06	16.5	21.05	26.05	31.05	08.10

Optimal temperatures for *Anopheles* mosquito activity are most characteristic of Ukraine's Southern region, potentially creating vector hotspots. Currently, Ukraine's climatic characteristics indicate a moderate malaria spread risk. Temperature forecasts to 2030 suggest a possible risk increase, underscoring the need for adaptation measures.

Ukraine is currently non-endemic for malaria parasites. Four mosquito species pose potential threats: *An. messeae*, *An. atroparvus*, *An. plumbeus*, and *An. hyrcanus*. Each species' existence is temperature-dependent. The primary pathogen, *P. vivax*, can spread to moderate latitudes and largely determines Ukraine's malaria incidence. Temperature is crucial in assessing territorial malaria potential, as malaria mosquitoes cannot regulate body temperature and rely on environmental conditions.

From 1991 to 2010, Ukraine's average annual air temperature rose by 0.8°C. Climate forecasts predict further increases, with Shevchenko projecting an average annual temperature rise of 0.44°C by 2030. Aggregated data from 1991 to 2023 and projections to 2030 are in Table 7[12].

Table 7

Possibility of Malaria Plasmodium Sporogony Completion in Summer, Ukraine

Region	Air Temp (1991–2010, °C)	Air Temp (2011–2022, °C)	Projected Temp Change by 2030 (°C)
North	+18	+18,2	0,45
West	+17	+18	0,41
Center	+18	+18,2	0,44
East	+20	+20,1	0,50
South	+22	+22,3	0,43

[12] О.Г. Забарна, О.О. Халаїм. Оцінка впливу температурних показників на формування маляріогенності території України. Національний університет «Києво-Могилянська академія» Інфекційні хвороби.2016. Випуск 4. С.86-92 https://surl.li/orudbp. С.71.

Climate change can significantly alter malaria vector distribution, creating favorable reproduction conditions. Monitoring spatial distribution changes is crucial. Sporogony stages in mosquitoes are temperature-dependent, with minimum development temperatures of 16.5°C for *P. malariae*, 17.5°C for *P. vivax*, and 18°C for *P. falciparum*. Ukraine's average winter temperatures range from -4°C in the Northeast to +1°C in Crimea, with a projected increase of 0.44°C by 2030, still insufficient for sporozoite formation.

In summer, average temperatures range from +17°C in the West to +22°C in the South and Crimea, suitable for *P. vivax* and *P. malariae* sporogony but not for *P. falciparum* in the West. Thus, Ukraine's malaria potential depends on summer temperature fluctuations.

Analysis shows that *Anopheles* mosquitoes thrive at 25–30°C, conditions nearly met in Ukraine's South and Crimea (22°C, projected to rise by 0.43°C by 2030).

Currently, Ukraine faces a moderate, persistent malaria spread risk due to extended periods above 15°C, facilitating multiple sporogony cycles. *P. vivax* sporogony duration is shortest in the South (15 days), increasing infection risk. The Southern region is most favorable for new outbreaks, with sporogony projected to shorten to 13 days, enhancing transmission intensity. With 183–189 days above 15°C, the epidemic season is relatively long, creating a high-risk zone.

In conclusion, wartime conditions and climate factors in Ukraine indicate a moderate, stable malaria spread risk, with projections suggesting increased risk by 2030.

CONCLUSIONS

In Ukraine, malaria transmission is potentially facilitated by five species of malaria mosquitoes, with *Anopheles maculipennis* (Spotted Anopheles) being the dominant species.

Ukraine's climatic conditions, including temperature changes exacerbated by military actions, provide favorable environments for the complete sexual development of *P. vivax* and *P. malariae*.

Temperature is a critical factor in determining Ukraine's malaria potential, indicating a moderate and stable risk of malaria spread. Predicted temperature changes suggest an increased risk of disease transmission by early October.

If infected mosquitoes appear, the likelihood of infection sources will rise, and the spread of *Anopheles* mosquitoes could facilitate pathogen transmission, potentially leading to local disease foci.

SUMMARY

This study assesses the risks of malaria spread in Ukraine following the destruction of the Kakhovska HPP dam due to military conflict with Russia. Temperature regimes are identified as the key determinant of territorial malaria potential. Analysis reveals that Ukraine's climatic conditions, particularly temperature, favor the development of *P. vivax* and *P. malariae*. Projected temperature changes in October may heighten disease transmission risks. The presence of infected individuals and *Anopheles* mosquitoes could lead to local malaria foci. Thus, Ukraine's temperature conditions contribute to a moderate, persistent risk of malaria spread, necessitating enhanced epidemiological surveillance and preventive measures.

Bibliography

1. Безсимптомна малярія, еритропоез та плазмодій / В. І. Павліченко, О. Б. Приходько, Т. І. Ємець, Г. Ю. Малєєва // *Екологічні науки*. 2022. N 1. С. 99-103. https://doi.org/10.32846/2306-9716/2022.eco.1-40.18.

2. Martens P, Hall L. Malaria on the move: human population movement and malaria transmission. Emerg Infect Dis. 2000 Mar-Apr;6(2):103-9. https://doi: 10.3201/eid0602.000202. PMID: 10756143; PMCID: PMC2640853.

3. Верба Н. В. Малярія. *Сучасні теоретичні та практичні аспекти клінічної медицини: науково-практична конференція з міжнародною участю, присвячена 150 річчю з дня народження В. В. Вороніна,* Харків, 9-10 квітня 2020, С.75.

4. Нечипоренко О. В. До проблеми малярії в Україні / О. В. Нечипоренко, Н. В. Анциферова. *Актуальні питання експериментальної та клінічної медицини*: матеріали міжнародної науково-практичної конференції студентів, молодих вчених, лікарів та викладачі, Суми, 25–26 квітня 2007 р. Суми, 2007. С. 51–52.

5. Воронова Н.В. Кровосисні двокрилі (Diptera) степового Придніпров'я: монографія / Воронова Н.В., Горбань В.В., Павліченко В.В. Запоріжжя: ЗНУ, 2008. 208 с.

6. Шевченко, О. Оцінка вразливості до зміни клімату. *Кліматичний форум східного партнерства та Робоча група громадських організацій зі зміни клімату.* 2014. 61 с. https://surl.li/kfvohm

7. Польовий, А., Божко, Л., Дронова. Аналіз тенденції змін термічних показників агрокліматичних ресурсів в Україні за період до 2030–2040– 2011.№9. С.90-99. http://nbuv.gov.ua/UJRN/Uggj_2011_9_13

8. О.Г. Забарна, О.О. Халаїм. Оцінка впливу температурних показників на формування маляріогенності території України. Національний університет «Києво-Могилянська академія» Інфекційні хвороби.2016. Випуск 4. С.69-71 https://surl.li/orudbp.

9. Воронова Н. В. та інші. Епідеміологічне значення кровосисних членистоногих рекреаційних зон Північно-Західного Приазов'я. Вісник Запорізького національного університету. Запоріжжя : ЗНУ. 2009. С. 126.

10. Voronova N. V., Tiutiunnyk M. O., Kulik A. . The role of blood-sucking mosquitoes in the transmission of pathogens of various etiologies. The 8th International scientific and practical conference "Scientific research in the modern world" Canada: Perfect Publishing, 2023. C. 27-30. URL: https://surl.li/kcuaap.

Information about the authors:
Voronova Natalia Valentinivna,
Candidate of Biological Sciences,
Associate Professor, Department of General and Applied Ecology and Zoology
Zaporizhzhia National University
66 University St., Zaporizhzhia, 69011, Ukraine

Horban Valerii Vitaliyovych,
Candidate of Biological Sciences,
Associate Professor, Department of General and Applied Ecology and Zoology
Zaporizhzhia National University
66 University St., Zaporizhzhia, 69011, Ukraine